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# Conversion as an Option

By

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# ABSTRACT

The following thesis examines conversion as a suitable option in response to market requirements, as an alternative to building a new or to acquiring an existing vessel. While conversions often appear as an option in the industry, little has been said about them and the methodology they should follow. The thesis investigates and proposes a methodology that can be used to evaluate the techno-economic feasibility of converting a vessel.

The thesis begins by discussing why and in which cases a conversion may be considered and examines why they should be looked upon with favour. It is acknowledged that conversions are not a new thing but have played a significant role thought maritime history by presenting several examples. A number of noteworthy conversion projects that have taken place in the industry, in more recent days, are then presented and discussed. The reasons behind conversion are examined and identified, and conversions are categorised in a number of types. A methodology is next presented for considering the conversion of a vessel.  The methodology begins by evaluating the conversion option against building or acquiring an existing vessel. After the decision for conversion has been taken, a process that will shape the conversion and prepare the ground for analyzing the investment commences.  In order to define the conversion characteristics, the reasons for conversion are thoroughly investigated and in combination with a broader market analysis a set of factors influencing the conversion are identified. Based on these factors conversion candidates are evaluated and a decision for conversion is taken on a cost and time basis while also considering other possible implications. The effectiveness of the methodology proposed is further examined in two case studies. Case study I considers a conversion targeting a certain cargo while Case study II considers a conversion as a result of regulation change. The outcome of the thesis investigation is discussed concluding that even though each conversion is unique and will heavily depend on the experiences of the individuals involved, a certain methodology for evaluating them can be followed that appears as a result of rational thinking.

# CONTENTS

**Chapter 6**

# CHAPTER 1 INTRODUCTION

The global circulation of goods, services and capital, but also of information, ideas and people has shaped the 20th century. Global forces of economy integration, have contributed to prosperity and development transformation. Despite a population increase from 1.8 billion to 6 billion, and despite giant political upheavals and wars, real average income per person has at least quintupled over the last century and the life expectancy has increased drastically [1].

The worldwide economic buoyancy at the turn of the 20th century created a physical demand for shipping transportation tonnage. Demand was such that it exceeded supply [2]. A variety of factors ranging from the rapid expansion of developing countries to international trade agreements, led to a tight supply of tonnage in the ocean shipping market with enormous benefits for ship owners and shipbuilders across the world [3].

From 2003 until 2008 increased charter rates and sustained market euphoria, created a frantic pace for placing orders for new vessels. The new building order book swelled to record proportions while all new building slots of reputable shipyards were booked for long periods [4]. As a consequence, following the market trend, the cost involved in ordering new vessels reached market highs, and the time from order to delivery increased significantly [5].

In a “sellers market” such as the above, with shipyards around the world dictating the terms for producing the end product, preferential treatment is shown to customers that are willing to adopt “standard” designs and building specifications without many variations. Yards develop and build their own standard designs of different types of vessels, increasing their productivity and profitability by building series of vessels and allowing only small variations from one vessel to the next. The practice of standardization that yards adopt serves productivity, and building efficiency, while the yard can build on its experience, eliminate problems and improve areas of concern that arise in the first vessels of the series. One-off designs tend to be avoided as they disrupt the chain of production and do not promise significant economical benefits in the long run. These types of vessels are normally built in specialized shipyards at an increased premium [3].

This however is not the case in a “buyers market” which characterized the greater part of the 20th century. As in any market, a scarcity of buyers means that the sellers must have particularly attractive goods on offer if they are to make the exchange [6]. Such being the case shipyards will compete on delivery time, quality and cost. In many cases, shipyards may not be concerned about making a profit but will quote depending on various other political and strategic criteria [3]. With competition existing between yards, buyers are in the position of negotiating a more favourable contract and demanding higher specifications [7].

Business success in any part of investment lays in the timely and dynamic response to any sign of market requirement and opportunity. A “sellers” shipbuilding market may prove to be an insurmountable barrier for owners requiring a certain type of vessel in response to market forces of the time. It has to be appreciated however, that even in a “buyers” market, from procurement to delivery of a vessel a certain amount of time is involved. In any case the will to invest in an expensive product with uncertain returns and future, such as the shipping market, is not always strong.

As ships become more expensive or as time constraints are considered, converting an existing vessel may prove to be an attractive option [8].Converting a vessel is not a new idea and conversions of one sort or another have always taken place in the shipping industry.

Ship conversion, will normally take place in a ship repair yard. Similarly to new building, market conditions will identify the availability of suitable ship repair yards for the conversion job considered. In a prosperous market, owners will appear keen to invest in the repair and life extension of older vessels that have completed, or are close to the completion of their life cycle. As a result, ship repair yards will see contracts involving extensive steel repair and paint correction actions, which in other times would have been impracticable and uneconomical. Swelling numbers of new building vessels entering the market coupled with minimum scrapping rates will further reduce available repair space [8, 9]. Moreover, overbooking of yards will extend the repair period and affect the quality of work.

Setting up a shipyard and transmitting the necessary know-how to the workforce either in the repair or the new-building sector requires years of practice. As the world fleet and repair demand increases, capable ship-repair yards having the necessary experience to undertake major conversion projects will become relatively scarce. In many cases owners will often be left with no option other than having to select yards of substandard qualities which will have an immediate effect on the end product.

The real economic world is so complex that even the most skilled analyst using sophisticated models can only talk in terms of broad trends, and even then they allow themselves quite a considerable margin of error. The capability of responding rapidly to a market opportunity will determine the success of any investment. In many cases, it may prove possible to fulfil the requirement for a certain type of vessel not by ordering a new vessel but by converting an existing one. As every conversion is a unique project which depends on the purpose it has to fulfil, a number of different factors have to be identified and examined on a case to case basis.

In the following thesis, types of conversion and the option of converting a vessel as an alternative to new-building or second hand purchase will be examined. A methodology for evaluating the techno-economic feasibility of converting a vessel will be proposed and its effectiveness will be demonstrated by case study.

# CHAPTER 2 AIMS & OBJECTIVES

The overall aim of the project is to investigate an effective methodology in evaluating the techno-economic feasibility of converting a vessel.

The more specific objectives of the project are as follows:

- To study the feasibility of conversion as an alternative to building a new vessel or acquiring an existing one.
- To identify the factors that should be considered when examining a conversion option.
- To propose an evaluation methodology for considering conversion as an option as a result of rational thinking.
- To demonstrate by case study the effectiveness of the methodology proposed.

# CHAPTER 3 CRITICAL REVIEW

In the shipping industry along with ongoing new buildings and repairs of vessels, a number of conversion projects may also be noticed. Conversions can be considered as something in between building a new and repairing an existing vessel. Many features of both new buildings and repairs can be noticed in a conversion. Conversions may involve extensive design and construction work as for a new building, in parallel to upgrading work and maintenance which is standard practice during repairs of vessels. They are therefore often not straightforward projects.

Whereas in shipbuilding and ship repairs there is no real problem in estimating progress and completion dates, the same does not apply for conversion projects. With a conversion one starts with a ship that is one hundred percent. Then, as you rip out, modify and replace, you actually push the ship back into time, and then it has to come forward again. It is very difficult to walk aboard a conversion and say this is ten or fifteen percent complete [1].

Why would someone consider then converting a vessel? As it is clearly seen in every day life, when coming to choose between a new and a second hand item, every person would choose the former. There is more confidence that a new product will fulfil better its purpose, looks better, is more reliable and most importantly is almost always covered by a guarantee for replacement and repair in case of failure. However, once the cost parameter comes into the equation, many, depending on their financial status would choose the latter. Other parameters are also then considered such as the role the item is intended to fulfil, its delivery time and life expectancy. In a similar manner the above applies to ship owning. An owner will always prefer a new vessel that is not expected to cause problems, will have minimum running costs, and is built to the exact specifications required to fulfil its role. Cost and time constraints however may lead him to choose otherwise. Conversions are often faster and cheaper than building a new vessel or even acquiring an existing one.

Comparing converting to building an existing vessel, the above is certainly true for “minor” conversions. For the majority of “major” conversions, as these are defined by

MARPOL [2] [Appendix 1], this condition also applies. Exemptions however exist, where only one out of the above two conditions apply, and therefore a conversion might be either faster or cheaper than building a new vessel and not both. Furthermore, when comparing converting to buying an existing vessel, more than often only one of the above criteria will apply, independently from the conversion being “minor” or “major”. It is needless to say that when neither condition is true, conversion is not considered.

Throughout market history, it has been very difficult even for the best of analysts to predict the market’s next step as there is always a big factor of uncertainty. It is thus frightening for many owners to consider the cost involved in a new-building investment and the time that will elapse before it will start bearing fruit. Periods of market history with fierce competition between new building yards exist, while periods also exist when yards have the ability to dictate terms and conditions and selectively pick their costumers. Availability of shipyards, during market peak periods, is scarce with a long waiting period normally involved, while shipyards will also prefer to stick to their standardised designs with which they can maximize profits. The key to success however, has always been targeting the right venture at the right time. Even in the days when new building options can be considered, there is always a time delay involved in the design and construction phase of a ship. It cannot be assumed that the need for a certain product or service will still exist after a shorter or longer period [3]. The same applies in the repair sector. During market peaks the number of repairs will multiply as owners are willing to invest in extending the lifespan of their vessels, and thus continue to take advantage of the good market. Conversions are normally done in ship repair yards. Repair yards prefer conversion projects as they normally involve a more extensive work scope offering better returns than standard repair projects. This being the case, it can be said that even during market peak periods, repair yards are more readily available to accommodate conversion projects compared to repair projects, as conversion projects are particularly attractive goods.

When examining any investment project including a conversion, the importance of time and cost against the market opportunity in the current state of the market must be considered. Speed against cost is often looked upon favourably if advantage of a current market situation is whished to be taken. In a same manner cost against speed can be favoured, when it is believed that the market opportunity will continue to exist or will arise at some point in the future.

In many cases a conversion may fulfil the purpose of testing a new technology reducing the capital investment risk. Further to this a conversion may extend the lifespan of a vessel that would be otherwise phased out due to changes in regulation or technology, and may prove a good solution for specialized and custom-built vessels.

Converting a vessel is not a new thing and one can see that conversions have been particularly popular in the military. Throughout military history it has been a normal practice for navies to convert merchant ships into fighting ships in times of emergency. One of the first historic reports documenting a conversion was the addition of a ram on war galleys. Competition for dominance in maritime trade between the Phoenicians and the neighbouring Greeks in the 9$^{th}$ century B.C. led the Greeks to arm their galleys with a ram, a sharp spike that extended forward of the ship below the waterline. Encased in bronze, the ram could be driven into an enemy vessel to disable or sink it [4]. In recent times ***USS Langley*** (CV1) was the first aircraft carrier of the US Navy converted from the collier ***USS Jupiter*** (AC3) in 1922 for experimental purposes. In October 1922 she launched, recovered, and catapulted her first aircraft during initial operations in the Atlantic and Caribbean areas. This opened the way for further development of aircraft carriers which still play a significant role in modern military history [5]. Two of the greatest liners ever built, ***Queen Mary*** and ***Queen Elizabeth*** of Cunard lines, were converted into troop ships during WWII. The speed and carrying capabilities of the two vessels proved to be vital for the fast and efficient transportation of troops to the conflict areas. By the end of the war the two liners had transported over two million troops to the war zones [6].

By looking up historical information on merchant vessels, it is evident that conversions have played a significant role in modernizing vessels as marine technology advanced. Some examples of many that have taken place follow. The wooden sloop named ***Frances*** built in 1848 was re-rigged twice in her lifetime first as dandy in 1852 and later as a schooner in 1871 and operated until 1883 when it was broken up at Westray, Orkney Islands [7]. Similarly the paddle vessel ***Pharos (V)*** built in 1854 was converted to a sailing barque and renamed ***Valletta*** in 1875 operating like this until it sank after a collision in 1877 [7]. More recently the steel twin screw steamer ***Pole Star (II)*** built in 1930 was converted to burn oil fuel in 1950 and operated until it was scrapped in 1965 [7].

A number of noteworthy conversion projects that have taken place in the industry more recently are next presented and discussed.

***Pure Car and Truck Carrier Elongation***

The relocation of many car manufacturers in countries of low cost labour has prompted an insatiable demand for car carrying space [8]. Wallenius Lines AB, along with its continuous new building programme in Daewoo Shipbuilding and Marine Engineering (DMSE) in 2005 embarked on a lengthening programme for five of its pure car and truck carriers (PCTC). The project involved the installation of a 28.80 meter-long midship section which increased the car loading capacity of the vessels by 20% (7,352 units from 6,125 units) [9].

After some preparatory work was completed, the vessels entered the dry-dock where they were cut and the forward hull section was floated out. The new midship section and the forward section were then floated back into the dry-dock in sequence, and positioned adjacent to the aft section. The position of all the hull sections was then carefully adjusted and the water pumped out of the dock. Finally the three sections were welded together. In parallel with the elongation sequence, the midship section for the next ship was started in the dry-dock. The first two ships in the sequence were redelivered within 45 days, while a conversion period of 40 days was achieved for the remaining three vessels in the series [10].

Following the conversion, the vessels became the largest vessels registered in Sweden on the basis of gross tonnage, which increased from 57,018 to 66,624 tons. The service speed of the ships remained the same and the deadweight increased from 14,957 to 19,000 tonnes. It is estimated that the five conversions were worth a total of $40 million [10].

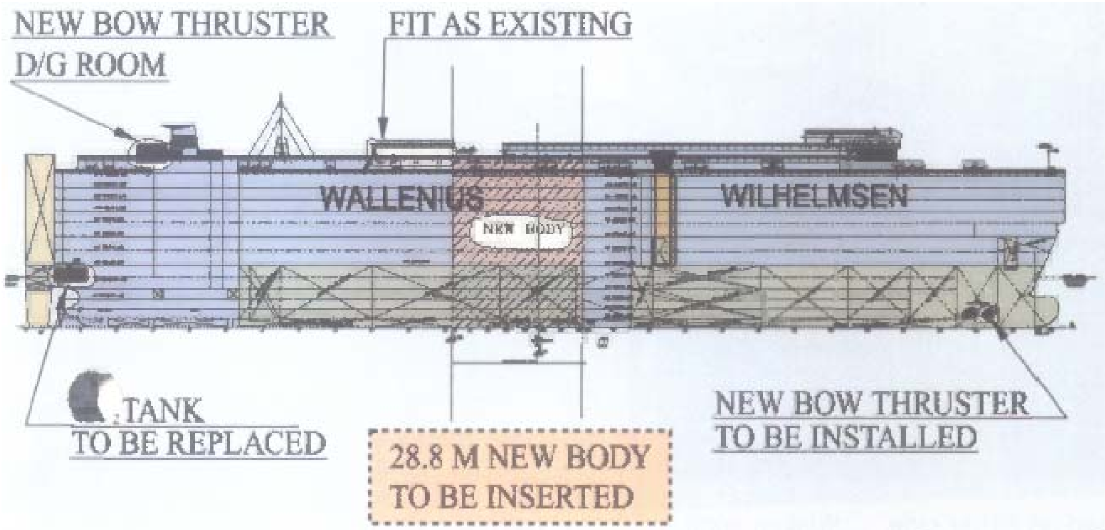



Figure 5-1

PCTC Elongation [10]

The above conversion aimed to increase the capabilities of the vessel in a continuously growing market. This method of conversion, i.e. installation of a mid-ship section in order to increase capacity, is becoming increasingly popular nowadays and is encountered in many other conversion projects across the industry.

It is interesting to highlight that all converted vessels (***Mignon***, ***Electra***, ***Boheme***, ***Manon***, and ***Udine***) were new vessels, built by DMSE in Korea and generally delivered in 1999 with the exception of the ***Udine*** which was delivered in 2003. Moreover, Wallenius was employed in a continuous new-building programme with vessels of increased capabilities scheduled to be delivered in following years [10]. Despite these facts and noting that the vessels were in their peak of their earning ability, increased demand for bigger capacity led the owners to the commercial decision of temporarily removing from the market and converting all five vessels. The ability to respond rapidly to market forces will determine market leaders and this is well illustrated in the above example.

***Jumboisation of a Heavy Lift Vessel***

Heavy Lift Vessels (HLV) are specialised ships used to transport units of significant size and weight. Their size and capacity makes ships of this type suitable for transporting offshore rigs, floating docks, container cranes and other large structures in one piece with high security. Loading/ unloading can be performed by float-on/ float-off, ro-ro, skid-on skid-off and lift-on/ lift-off methods, or any combination of these. Horizontal submersion to depths of over 10m over the open cargo deck is possible, with accurate control ensuring minimal stresses on the load during ballasting and de-ballasting operations [11].

The increasing demand for utilisation of natural oil and gas resources from remote areas of the planet (deeper and more hazardous waters) leads to an increase in size and capacities of the offshore platforms involved. That is, the future rigs will be larger and heavier than the existing ones. Under this perspective the size of HLV will also increase, in order to comply with the demand of transporting successively heavier modules from the shipyard to the appropriate location [11]. HLV offer oil companies the transportation of fully integrated units to their final destination, eliminating final assembly, hook up and commissioning on site. Fully integrated units can now be located at any location of choice, regardless of distance to site [12].

In this manner HLV shipping company Dockwise decided in 2003 to boost the transporting capacity of ***M/V Blue Marlin***. The ***Blue Marlin*** and its sister ship the ***Black Marlin*** were originally designed to transport very large semi-submersible drilling rigs, both vessels having a deadweight of 57,000 tonnes. After conversion at Hyundai Mipo Dockyard in Ulsan, South Korea the ***Blue Marlin*** re-entered service as the world's largest HLV. The particulars of the vessel prior to and after conversion are presented below [13].

| ***M/V Blue Marlin* pro versus post conversion characteristics** | | |
|---|---|---|
| | Original specification | Converted specification |
| Length O.A. | 217.00 m | 224.50 m |
| Breadth | 42.00 m | 63.00 m |
| Depth | 13.30 m | 13.30 m |
| Draft | 10. 11 m | 10.08 m |
| Deadweight | 56,000 tonnes | 76,061 tonnes |
| Max draft submerged | 23.33 m | 29.30m |
| Free deck area | 7,215 $m^2$ | 11,227 $m^2$ |
| Propulsion capacity | 12,640 kW Main Engine | 12,640 kW + 2 x 4,500 kW Retractable Thrusters |
| Bow thruster | 2,000 kW | 2,000 kW |
| Service speed | 13 knots | 13 knots |
| Cruise range | 25,000 nm | 25,000 nm |
| Building/ conversion yard | CSBC Kaohsiung | Hyundai Mipo Dockyard |

Table 5-2

Information obtained from the Dockwise website [13]

It is interesting to note that the decision to convert the ***Blue Marlin*** came after Dockwise was awarded a contract in 2002 for the sea transportation of the largest semi-submersible Production & Drilling Quarters (PDQ) ever to be built at the time (***Thunder Horse*** PDQ weighing 60,000 tonnes) [12].

Figure 5-3

MV Blue Marlin carrying Thunder Horse

Photo from Dockwise website [13]

Following conversion, the vessel was not made redundant as it is further used for the transportation of a variety of heavy cargoes, being the only vessel capable of doing so.

It has since been involved in the transportation of the Gas Refinery ***Snovhit*** from Cadiz to Hammerfest, the transportation of the massive Sea based X-Band Radar to Alaska and in the transportation of a number of other heavy cargoes [13].

The above conversion aimed to increase the capabilities of a specialised vessel. As it was pointed out, it was custom-designed targeting a specific contract which not only covered the cost of the conversion project but also generated a considerable profit. As the period between awarding the contract and undertaking the transportation task was very short, the conversion of a vessel seemed the only viable option. Thus, the largest HLV in the world was created.

***CSL Forebody Project***

The CSL Group is a Canadian based company which specializes in self-unloading bulk carriers (SUL) with inland, coastal and deep sea trading capabilities. The company serves clients in industries ranging from steel to agriculture with the largest fleet of SUL vessels in the world [14].

SUL form a special category of vessels which offer a number of advantages. They can discharge faster than conventional bulk carriers reducing turnaround time, alleviating berth congestion and reducing port and demurrage costs. Moreover, SUL do not require complicated or expensive port facilities and can operate around the clock without the expense of stevedores or clean up crews. They are also designed to meet the most stringent regulations for dust and noise pollution. They do, however, have an increased capital cost mainly due to the specialised unloading equipment that exists on board. This type of vessel is particularly popular in North America where high stevedore charges apply [15].

Following expansion in the company’s client base and subsequently the number of potential cargoes, a requirement for more vessels was generated in 2004. The company was then faced with the problem of new-building yard congestion, main engine availability and reluctance of shipyards to get involved in the construction of such a specialised and complicated design that could not be mass produced. It thus embarked on a conversion programme [16].

As the cost of acquiring second hand vessels at the time was also high, CSL decided to proceed with a very innovative conversion, taking advantage of new regulations that came into force and affected a different type of vessels: single side oil tankers. Revised paragraphs of Annex I MARPOL 73/78 set the 5$^{th}$ of April 2005 as the principal cut-off date for single side oil tankers [17], thus excluding from the market a number of vessels which were to be scrapped.

Based on some technical requirements, a number of these vessels were acquired, the plan being to retain the accommodation and engine room area and construct a new SUL forebody. The conversion involved the cutting of the vessel in two at the engine room bulkhead, scrapping of the forebody and cargo section, building a completely new forebody cargo section complete with self-unloading system, and joining together the new and old sections. Two Chinese shipyards were contracted for converting, initially, a total of four vessels [18].

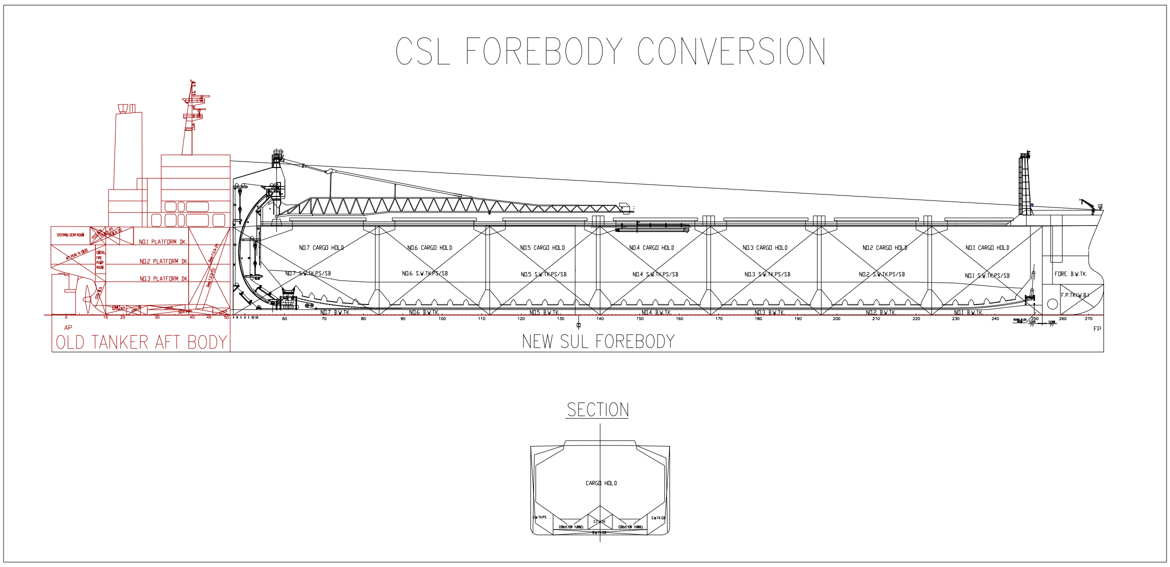



Figure 5-4

Forebody Conversion Project [18]

As SULs are a very specialized type of vessels with very expensive unloading equipment on-board it is common for them to undergo a number of life extensions in order to prolong their life cycle. It is noteworthy to say that CSL still operates vessels that came into service in the middle of last century. In other words the age of this kind of vessels will not compromise its commercial value.

The above conversion falls under the category of a specialized conversion. CSL managed to add to its fleet four vessels which complied with the latest rules and regulations for SULs, at a cost close to 2/3 of a new vessel and with immediate delivery. The success of the above project was such that the company continued with the conversion of an additional four ships [18].

In the above presented projects, the requirement for a vessel to fulfil a certain market opportunity is satisfied by conversion. Evidently, a conversion in many occasions proves to be a good solution to various time constraints, new building shipyard availability and specialised projects.

Moreover the above projects involve a complex plane of interfaces. The PCTC elongation involves a mere change to the vessels principal dimensions. The HLV principal dimensions are also altered while new machinery is also installed. The SUL carrier conversion tends more to new building with a complex plane of interfaces. It is recognised that ship conversion specifications are even more difficult to write than new-building specifications. The reason for that greater difficulty is that in ship construction the specifications and plans must only define the final product, but in ship conversion, the specification and plans must define both the starting point, i.e. the ship before conversion, as well as the end product [19]. Every conversion project will involve different interfaces that have to be managed. Engineering phases of the conversion will be interdependent and often some cannot commence unless another is successfully completed. Continuous adaptation of the design may thus be required as the conversion progresses and unforeseen complications come into light. In a conversion project existing features intended for a vessel of a different design must now be included in a new design while trying to maximise their effectiveness. Making use of the existing features and successful mixing of new and old technologies will have a direct reflection on the conversion final cost. Strong site supervision that will have a direct input in the construction and will be able to coordinate between design and production without delaying the project is vital.

The motives and driving forces behind any decision for conversion will vary from case to case. Vessel form and characteristics have continuously changed to satisfy particular needs of cargoes that they have at times transported. The ever-growing variety of cargoes with different properties and sensitivity dictates the need for specialised vessels involved in a particular trade.

Types of cargo transported are one of the most important factors influencing the final design and form of a merchant ship. A liquid carrier for example will have a completely different internal arrangement when compared to a dry cargo or container ship. Even with cargos of the same category, there will be differences in the facilities required on board. Transportation of fruit and meat, for example, will require entirely different refrigeration systems. One cargo has to be and remain frozen while the other requires continuous ventilation. Sometimes the requirements for more specialised cargoes may not be as obvious.

Converting a vessel in order to make it suitable for the carriage of a certain cargo, targeting a specific market sector is a very common reason for conversion. When considering a conversion for targeting a certain cargo, background information and cargo properties will form a major part of the conversion investigation. Cargo characteristics will determine the conversion options which will be to a lesser extent guided by other requirements.

Along with the ever-growing variety of cargoes, demand for certain commodities in an expanding market also increases. Orders for vessels of bigger capacity and size are becoming ever more popular while, equally important, characteristics concerned with the speed of operation are continuously improving. Under these circumstances it often becomes difficult for older vessels to compete with modern, more efficient designs, with a direct influence on their earning capability. Having said so, the expected lifecycle of vessels is reduced, as older vessels are no longer competitive, and special countermeasures are required in order to enhance their competitiveness. Conversion projects aiming to jumboise a vessel, enhance its propulsion characteristics, discharging capabilities and so on, in order to make it competitive or match certain market requirements, are often the case.

Performance improvement conversions will require a thorough examination of the market trends and future forecasts, factors that will guide the conversion requirements. Understanding of the future trends and providing a converted vessel that is competitive and will remain competitive for a period, will determine the success of the conversion. It can be argued that successful forecasting sets the ground for the success of every project.

As ships have evolved throughout centuries, rules and regulations governing their safe construction and operation have also evolved. Major accidents, often resulting in human casualties and great amounts of pollution, have, in many cases, played an important role in increasing the pressure for stricter regulations and enforcement practices. Research, coupled with the benefits of the advance in technology, has created a better understanding of the marine environment, providing knowledge that is fed back into the marine industry. Moreover, advance in technology has made simpler, more productive and safer ship construction and on-board operations.

It is often the case, when following the latest amendments of the regulatory frames that a series of modifications and changes are required onboard a vessel before a certain date, so that it can retain its trading certificates. Required modifications can be of any sort and kind, ranging from the simplest installation of a certain type of equipment on board to the complete re-organisation of the vessel's form and layout.

Conversions following regulatory requirements are very common. Good understanding of regulation is required so that it can be implemented in such a way for the vessel to comply and remain competitive with minimum downtime and cost. Regulation is a factor that has to be considered during any conversion.

The ever changing face of technology and commerce will sometimes require specialised vessels intended to fulfil roles in specialised trades. Unique operating conditions will shape technical features that are characteristic to each type of vessel. Furthermore, it is often the case that vessels of this kind are built for one-off operations and form part of a greater project. Due to the complexity involved in the construction of such ships, shipyards appear quite reluctant to build them and favour standardised designs. Consequently, wherever a conversion appears as a feasible alternative it is looked upon with favour.

The role the vessel is intended to fulfil and the special requirements of the particular trade will guide the conversion options. Specialised conversions may extend in areas where regulation has not been applied and standards have not been set. In such a case innovation will determine, to a certain extent, the conversion option, which will then become the standard for following designs. Setting of realistic targets is thus important.

Evidently a conversion project may also have the form of any combination of the above. This is often the case, as many projects are driven by a number of different reasons. Summarising the above, the reasons behind conversion may categorise conversions in the following types;

1. Conversion targeting a certain cargo
2. Performance improvement conversions
3. Regulatory conversions
4. Specialised conversions
5. Combination of the above.

In the following chapters a certain methodology for examining a conversion as an option will be proposed and will later be applied to case studies. As the examples of conversions presented are concerned mostly with performance improvement and specialized projects, the two case studies which are examined will be in the field of targeting a certain cargo and converting due to regulatory changes.

# CHAPTER 4 METHODOLOGY OF FEASIBILITY STUDY PROPOSED

A market opportunity that will generate a requirement for a vessel can only be identified after thorough market research. The deciding factor in proceeding or not with a project is the current state of the market, future projections and returns. Predicting future market trends, demand and supply is an uncertain and high risk process even for the most skilled analyst, as it is driven by a number of variable parameters and geopolitical events. It is not an exaggeration to say that the market success of a project depends highly on an element of luck. Nevertheless, investments require thorough market investigation based on demand, supply, going rates, projections and facts as much as possible. Any decision for proceeding with any marine project, including conversion, should be made after having considered all post-project market advantages and disadvantages [1]. Market research should be continuous and will not stop once a market opportunity is generated. As the market is a dynamic entity factors that may be important in deciding on a conversion project can be generated at any point through the conversion investigation process. Moreover as the investigation process will progress and more specific information about the conversion is generated, market research will become more specific as it will focus further on the project characteristics.

Once the requirement for a vessel has been generated an investor will be faced with the following options;

1. Building a new vessel
2. Acquiring an existing vessel
3. Converting a vessel

Every investor would like a vessel that is custom built to a specification that fulfils the trade requirements and generates the maximum profit. A new vessel, built according to market requirements, will do this in the best way. To a certain extent this condition can also be met by acquiring an existing vessel. An existing vessel is looked upon favourably in many cases, as acquiring it is faster and less complicated than a new building. For specialised projects or for latest changes in regulations however, acquiring a new vessel may not be an option. Converting a vessel may also be considered. An owner may consider converting an existing vessel of his fleet, or if this is not the case, acquiring and converting an existing vessel. There may be cases where conversion appears the only option, such as changes in regulations, where conversion may be the only way for an existing vessel to retain its trading certificates. The options available for satisfying the requirement for a vessel are evaluated at a very high level, making broad assumptions about the ship design, its general mission, and its physical and operational characteristics. This level is used to decide on the economic feasibility of each option and is heavily based on statistics, going rates for each option, and feedback as received from the industry making it very similar to the cost estimate process conducted during the concept design phase of a vessel [2]. The options are then compared on a cost and time basis and a decision is made. Financial, market, or even technical requirements [3] may prove to be prohibiting factors for building a new or for acquiring an existing vessel and converting a vessel may appear as the most suitable option.

Once the decision for conversion has been reached, a more detailed study, which will produce an accurate cost and time estimate and will eventually lead to the conversion specifications, should be conducted. The study should start by examining the reason for conversion. As it has been already pointed out, the reasons for conversion will categorize conversions in certain types. The type of conversion will direct research which will shape the required characteristics of the converted vessel and will define the design. More specifically:

1. For conversions targeting a certain cargo, research should be directed in examining the characteristics and special features of the cargo.
2. For performance improvement conversions, research should be directed in examining future forecasts and trying to predict the optimum vessel characteristics for the forthcoming years.
3. For regulatory conversions, research should be directed in understanding the regulation and examining its extent and applicability.
4. For specialised conversion, research should be directed in indentifying the special features and understanding them.

5. Research should be directed accordingly for any combination of the above.

By directing research based on conversion type, key requirements that will influence the design can be identified and their importance assessed, forming a basis for the design process. Research will also form the basis on which the candidate vessel will be selected and the conversion design will be expanded. It may be the case that the candidate vessel already exists, so research will only form the basis for an optimum design according to the characteristics of the existing vessel. While the conversion type will direct research, research should also be expanded in a broader perspective to ensure that certain factors are identified that will safeguard the competitiveness of the vessel in the market environment.

Converting a vessel is not considered a new building, no matter the extent of the work scope. When selecting a candidate vessel it is thus critical, also to examine if the expected lifespan of the vessel will be compromised by the vessel's age. New built vessels are normally designed for a 25 to 30-year lifespan [4]. At the end of the vessel's designed life, most of its mechanical and structural elements require either replacement or a major investment for reconditioning. Other than this, times of low demand may come, creating difficulties in chartering older vessels. In "tight" markets charter rates will fall and preferential treatment is shown to younger, more modern vessels. Especially in the case of a vessel engaged in the trade of transporting sensitive cargoes, charterers and port states may often apply age-dependent cut-off dates. In certain trades such as the oil trade, continuous assessment of the vessels is required after a certain age and is regulated by special schemes (i.e. CAP, CAS surveys). Age related cut-off dates do not apply so much to the sector of specialized trades as specialized vessels intended for a specific trade are in many cases low in numbers and difficult to acquire.

Based on the candidate vessel, it is also useful to examine whether the conversion considered is a major conversion as defined by MARPOL [Appendix 1] [5, 6, 7] In the event that the conversion satisfies the requirements and is considered as major, the complexity of the project will increase. Latest rules that apply to the construction of new buildings will also have to be incorporated in the designed modifications for the converted vessel. A clear understanding of latest rules and the way that they can be applied to the conversion should be established. Even in the case that the conversion of a vessel is not classed as a major conversion this will not automatically imply that it is a simple and straightforward procedure. The complexity of each project will depend on its specification. Nonetheless rules that came into force before the construction of the vessel should still be carefully examined to ensure that the vessel will still comply with them after conversion.

After selecting a candidate vessel the conversion should be expanded in two directions; the actual conversion and the repairs. Most conversion projects are normally combined with a life extension programme, adding value to the vessel and safeguarding the conversion investment. Depending on the condition of the vessel, the life extension programme will form a major part of the project cost. It may thus become the deciding parameter for proceeding or not with the project.

The current condition of the vessel will depend on its construction and operational history. The standard of the initial building specification and the quality control during construction of the vessel are very important. Parameters such as the structural scantlings (above minimum required), painting scheme applied, surface preparation, type and maker of equipment installed (reliability and experience) and, in general, any improvements undertaken during the construction stage reflect the potential of the vessel [8]. Moreover, the type of vessel, the cargoes it carries, its loading pattern and the area of operation are contributing factors to the fatigue life of its structural elements. The chemical properties of the transported cargo and the frequency of transportation may also have detrimental effects on the integrity of the vessel. Most importantly, quality and number of the manning crew, and the time available to undertake maintenance work during the operation of the vessel will make a difference. The part of the budget that the owner has allocated for crewing and maintenance are thus important. The level of maintenance in particular of the vessel's structural elements, is closely related to the size of the vessel and its design [8]. Ballast tanks of smaller vessels can be maintained easier than those of larger vessels during their operational life, as their space is limited and generally easier accessible. The design of the vessel providing permanent means of access in all spaces to assist inspection and maintenance plays an important role. The amount of work involved in the upgrading process and the time involved will have a direct impact on the conversion cost. If this is considered to be excessive in proportion to the actual conversion cost and time, a new candidate vessel may be selected. Careful selection of the candidate vessel will, therefore, determine the success of a conversion.

Based on the initial specification of the candidate vessel, different conversion options will exist. Starting from the most basic to the most sophisticated option, requirements can be met to a greater or lesser extent. The options that satisfy the key requirements while giving special consideration to other parameters such as the operation, environmental friendliness, safety and risk involved, will be further evaluated. For any conversion a design study will be required. Generally speaking, the design process for a conversion will be very similar, but with more fixed variables, to the design process for a new vessel, being an iterative process [9]. Cost estimation can be successfully integrated with the design engineering process to produce trade-off studies useful for developing an appropriate direction for the ship design [10]. The capital available for a certain project and the size of investment the owner is willing to make will determine, to a certain extent, the final design, and will limit the designer to the conversion options he is able to propose. Eventually viable options will be evaluated on a cost and time basis, taking into consideration the extent to which key requirements are satisfied and possible other implications that may appear for different options. The results of the study may lead to selection of a different option or even a different candidate vessel. Depending on the conversion project, a certain cost will be involved for the design study. In the preliminary stages and for assessing the feasibility of a conversion project the design cost will not be very big. If however the decision is taken to proceed with a conversion project and detailed designs are required, the design cost will escalate forming, in many cases, a considerable part of the conversion cost. Either way the design cost both during the feasibility study and the final design should be accounted for.

Once the investor feels happy with the results of the conversion and upgrading study, costs and time will have to be combined to present total figures. The total time required will represent the projects downtime.  Downtime is an important factor in each and every aspect of vessel operation and signifies the loss of potential earnings of the vessel due to various unforeseen or planned events. An indirect but significant cost related to conversion project is the downtime and loss of earnings that will result while the vessel remains in the yard and out of service.

An investment analysis of the complete conversion study will follow. The investment analysis will produce a decision based on the results of the conversion study of the candidate vessel while checking against the key requirements and market factors generated during the conversion research. If the results of the investment analysis are not satisfying, a different candidate vessel may be selected and the same process will be followed again. There is no universally agreed technique for weighing the relative merits of alternative designs or strategies. Any commercial conversion should be worked upon with the goal of maximizing its profitability as an investment. Nonetheless even non-commercial conversions, such as for military or service functions often undertaken by the government, should aim for the least cost that will successfully and safely perform the required task. It must be appreciated that an economic analysis as an extension of a preliminary design or a feasibility study, serves merely for weighing factors for decision making. Simplified assumptions are safe to be made before passing the study to experts that can include in the analysis financing models, taxation systems, depreciation models and so forth. There are good arguments for each of several economic measures of merit that can be used. From an engineering perspective what has to be proven is that a proposal will generate a profit and between alternatives to show which one promises to be more profitable. For commercial conversions and for assessing if the project will generate a profit within its commercial life the ‘pay back period’ (PBP) is considered adequate. This answers the invariable question of ‘how soon do I get my money back?’ In the case that ‘pay back’ falls within the vessels commercial life, a profit is ensured and hence the investment is economically viable. This can form the base for decision making. After this base has been formed, different economic models simplified or not, can be used for a better understanding and a broader view of the complete investment [1, 11].

Specifications can now be prepared. The role of the specifications is to identify and describe the exact scope of work and owner’s requirements, in such a way as for the yard to be able to understand and provide a quotation for each item identified [12]. The specifications will be sent to a number of yards and their quotations will be compared. The specifications should be precise and should try to cover all eventualities and possible requirements that may arise throughout the project. In this way a realistic budget can be prepared, and the relevant financial resources allocated.

The actual condition of the vessel should thus be evaluated throughout, before proposing a repair plan. The use of a pre-qualification questionnaire (PQQ) incorporating outline specifications can be used before the final specifications are sent out, in order to reduce the range of potential shipyards to a manageable short list. This action can also take place before the conversion option is finalised, as part of cost estimating during the design process, in order to get more realistic figures of the conversion costs involved.

The specifications, upon which the quotation will be based, should be prepared well in advance before the project commences. By doing this the most competitive price and time offer will be obtained. As for any other well-managed and profit-making organisations, yards like to have their available slots booked beforehand, giving them time to organise and allocate their resources in the most efficient manner. Moreover, advanced quoting will provide the project manager the opportunity to re-negotiate with the yard on certain items and clarify “black” spots that may cause disputes during the repair and invoice-settling processes [12].

The choice of a suitable yard for conversion will be influenced by a number of factors. The obvious yards for consideration are the yards in the vessel’s area of operation. Significant financial and technical differences exist, however, between yards depending on their location. The scope of work should be carefully considered, the quoted period of time and cost from each yard examined, and the feasibility of possible repositioning the vessel investigated. Possible technical/financial and time benefits of repositioning can be singled out, when the costs associated with relocation and downtime come into the equation. Unless a suitable charter is found for repositioning the vessel, the downtime will multiply and may outstrip possible yard related savings or technical advantages. The ability of a yard to undertake a project successfully will depend on the yards previous experience and technical ability [13]. Depending on geographical location, project costs and technical expertise of the yards will vary greatly. Nowadays Chinese yards are preferred for projects involving a great amount of steel construction work, as they offer steel prices close to half that of the nearest competitor. Similarly Singaporean yards are currently the leaders in specialised offshore project conversions involving the installation of specialised equipment. The capital investment involved should be always weighed against the reputation of the yard. It may be unwise, for example, agreeing an offshore contract worth multimillion dollars with a yard that has never before appeared in this sector, no matter how appealing the economic benefits may be. Quality control and quality assurance of the end product are parameters that are not often ensured by budget prices [13]. The location of the yard in relation to different services/ subcontractors that will be used throughout the repair period should be also considered. The availability and delivery time of vital spares and services may have an impact on the project schedule [4]. Previous business history between yard and owner is also important. Good cooperation that led to successful completion of the repair and final settling of the invoice should be always appreciated and valued.

Timing for the conversion should also be kept in mind. Significant savings may occur depending on the time of year the project is launched. The contracts by which goods are normally transported include “spot” charters, “time” charters and “bareboat” charters [1, 14]. Charter hire rates are primarily a function of the underlying balance between vessel supply and demand. In certain trades, hire rates tend to be seasonal. As an example for oil tankers, during winter months in the northern hemisphere the demand for oil rises. Rise in demand subsequently leads to an equivalent rise in charter rates. The opposite effect takes place during the summer season when demand for oil declines leading to great differences between the charter rates of the winter and summer seasons. It is therefore common practice for ship-owners to tend to prefer dry-docking of oil tankers to take place during the summer period. This trend however causes yard congestion, often extending the repair period and affecting work quality. Market seasonal rates should be used as a “rule of thumb” as it cannot be assumed that they follow a strict pattern. Since the market is a volatile and dynamic entity influenced by geopolitical events, exceptions to the rule will apply. Appendix 2 shows a chart comparing the growth of sea trade and world GDP from which it can be seen that shipping is very vulnerable to world economic crises [1]. Seasonal rates and yard availability should thus be carefully examined and balanced.

Timing should also be examined in relation to class requirements for survey and repair of the vessel. For merchant vessels, according to class rules for surveys, there is to be a minimum of two examinations of the outside of a vessel’s bottom and related items during each five year special survey period (docking survey). One such examination is to be carried out in conjunction with the special periodical survey. In all cases the interval between two such examinations is not to exceed 36 months. Examinations of this sort are carried out when the vessel is in dry-dock. Consideration may be given to an alternative examination while the vessel is afloat by an approved underwater inspection, equivalent to a dry-dock survey. This however does not apply for oil tankers and bulk carriers of 10 years of age and above [15]. The docking survey is a major cost item during the vessel's lifecycle [8]. A shipyard with suitable docking facilities for accommodating the vessel has to be selected. The possibility of aligning the conversion jobs with the vessel's predefined special or intermediate survey commitments, which require dry-docking attendance, should also be thoroughly investigated.

When significant financial investments are considered, an agreed, signed and approved contract is required in order to safeguard both parties' interests and rights [12, 13]. A contract can have the form of a simple written agreement or may form an extensive document requiring the input of many parties and specialists. There are many formats of contracts with different levels of details. As a general guide, the chapters that may be included in the main contract for a conversion project are presented in Appendix 3 [16, 17].

The signing of a contract is one of the final steps before the commencement of a project and does not form part of the decision process when examining a conversion option. The existence and application of a good contract that will safeguard both parties' interests is however of paramount importance. It must be remembered that from the minute the vessel enters a yard and repair work commences, it is hostage to the yards "good will" [13].

The above is presented below in the form of a flow diagram in Figure 4-1. The process described in this Chapter and illustrated pictorially in Figure 4-1 is typical and must be adapted by users to suit the specific circumstances of any particular proposal. The case studies presented next in Chapters 5 and 6 illustrate this.

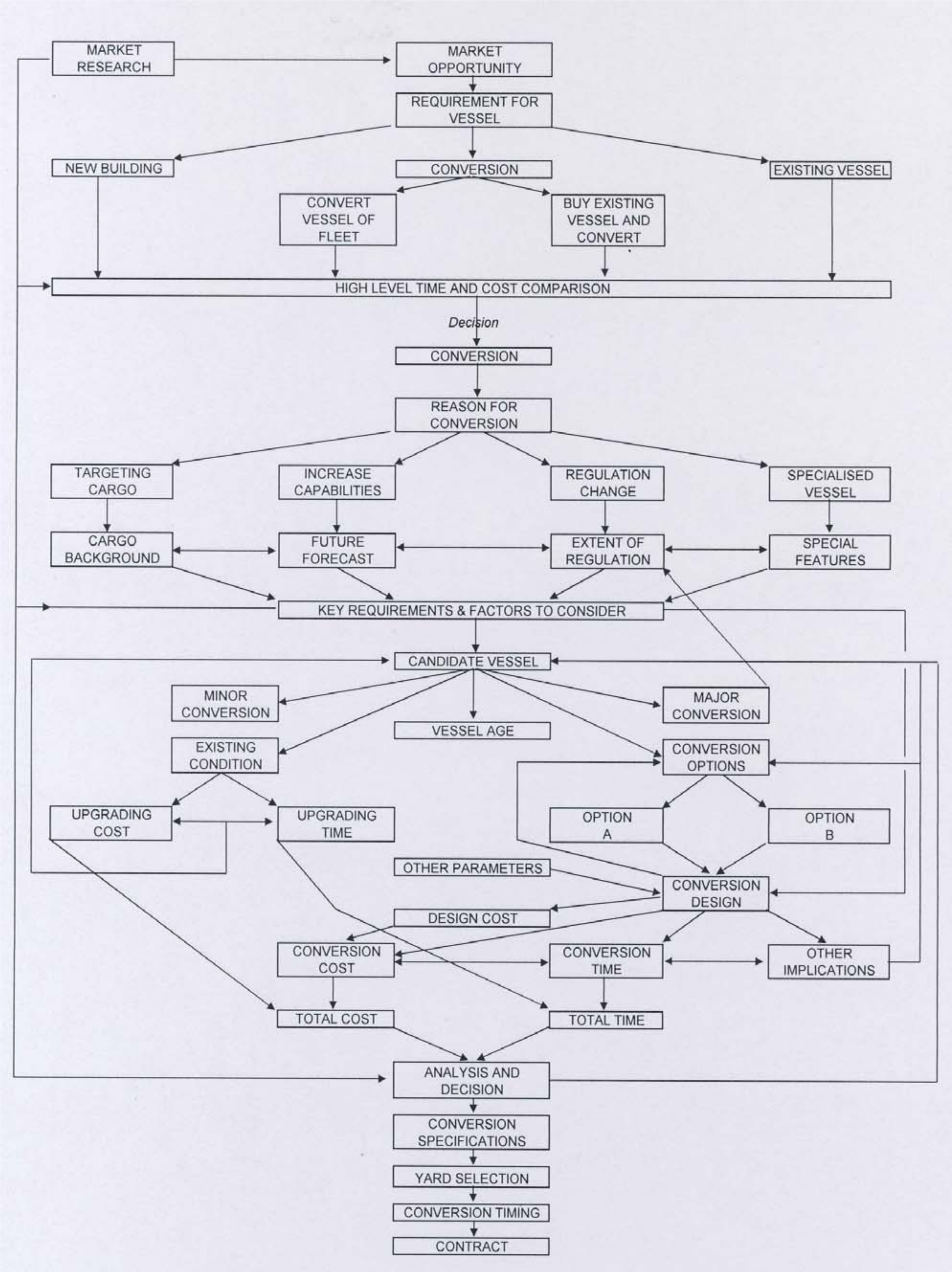



Figure 4-1
Methodology Diagram [1, 2, 4, 8, 9, 10, 11]

# CHAPTER 5 CASE STUDY I

In this case study, a preliminary investigation for the feasibility of a conversion is presented. The type of conversion considered is targeting a certain sector of the market. The period during which this investigation took place is the fourth quarter of 2006 and data from this period is used.

## 5.1 Scenario

An owner of a fleet of Aframax size crude oil carriers is looking to expand his business in markets of different cargoes. Market information suggests that transportation of large quantities of aviation fuel is an up and growing market. He is thus considering the possibility to convert a crude oil Aframax tanker from his existing fleet into an LRII Vessel.

## 5.2 Background Information

Transport of oil products is in many ways similar to that for crude oil but there are some important differences. One is that most of the trade moves in small tankers up to 60,000 dwt with coated tanks. The size restriction arises from the small parcels of oil products traded by the oil industry, the many short trades which limit economies of scale and terminal restrictions. However there are no firm rules about the size. Even very large crude carriers (VLCC) are occasionally chartered for long-haul parcels of fuel oil and many Panamax and Aframax tankers have their tanks coated and are specifically designed and built for the carriage of products. Panamax size product tankers are called Long Range I vessels (LRI) while Aframax size tankers are called Long Range II (LRII) vessels [1].

Focusing on the oil industry, it is evident that a number of different oil carriers of various types and sizes exist. Ranging from the smallest chemical/product carriers up to the largest VLCC, every vessel is specifically built and operated according to the type and amount of liquid cargo it transports. The most common types, and general distinguishing features, of existing oil tankers are presented in Table 7-1 [2].

| Tankers for all cargoes and trades | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Vessel** | PC MR | PC/ CH | P'MAX PC LRI | P'MAX COC | A'MAX COC | A'MAX PC LRII | S'MAX COC | VLCC COC |
| **Dwt (tonnes)** | 35-46K | 35-46K | 68-75K | 68-75K | 75-120K | 75-120K | 120-200K | 200-320K |
| **Cargo oil tanks P+S** | 12+ | 12+ | 6+6 | 6+6 | 6+6 | 6+6 | 5+5 | 5+5+5 |
| **Slop tanks** | 1+1 | 1+1 | 1+1 | 1+1 | 1+1 | 1+1 | 1+1 | 1+1 |
| **Residual tanks** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Cargo segregation** | 3- 12+ | 3- 12+ | 6 | 3 | 3 | 3 | 3 | 3 |
| **Pump room** | N | N | N | Y | Y | Y | Y | Y |
| **SUS pipes** | N | Y | N | N | N | N | N | N |
| **Corrugated bulkhead** | Y | Y | Y | N | N | N | N | N |
| **Stools** | Y | Y | Y | N | N | N | N | N |
| **Cargo tank coating** | Pure Epoxy | Phenolic SUS | Pure Epoxy | Epoxy UD+TT | Epoxy UD+TT | Pure Epoxy | Epoxy UD+TT | Epoxy UD+TT |
| **Longitudinal stiffeners on deck** | Y | Y | Y | N | N | N | N | N |
| **Inert gas** | IGG | IGG | IGG | IGS | IGS | IGS | IGS | IGS |

Table 7-1 [2]

Examining the above table, oil tankers are categorised depending on the amount (dwt) and type of cargo they carry. Depending on the type of cargo differences will exist even for tankers of the same size. The number of oil tanks on the vessels will not increase proportionally to the vessels size. As it can be seen from the table, smaller vessels seem to have a greater number of tanks which have separate pumping arrangements (no pump room). The reason for this is that smaller size tankers normally carry specialised varieties of oil products that come in smaller cargo parcels. Consequently a better cargo segregation system and more cargo oil tanks are required, some of which are specially coated to resist toxic and corrosive liquids (phenolic coating or tanks made from stainless steel). The separate pumping arrangements are usually submerged cargo pumps in the cargo tanks with designated lines assisting cargo segregation. Due to the specialised products that in many cases are very corrosive, the designated lines on these vessels are sometimes made out of stainless steel (SUS). The above do not apply to the larger size tanker vessels which normally transport large quantities of crude oil. Crude oil does not require the cargo tanks to be coated. To protect the tanks from sulphuric corrosion, from Sulphur that may exist in crude oil, only the tank top and under deck structures are coated to a certain extent normally with epoxy coatings [3, 4]. Complete cargo tank coating is only required for LRI and LRII tankers that transport oil products which are coated in a similar manner to the smaller product tankers with pure epoxy coating. Segregation of the cargo system allows normally three different types (or grades) of cargo to be carried. Larger tankers than Panamax size are equipped with central pumping arrangements in pump rooms. Pump rooms are compartments of the ship where cargo pumps, one for each grade of fuel, are installed. All types of tankers have two slop tanks. These are the tanks where oily water is stored after washing of cargo tanks has been completed and decanting takes place. Only chemical vessels have residual tanks in which chemical wash wastes which are prohibited to be discharged overboard are kept. In order to control the explosive atmosphere on tanker vessels inert gas is pumped in their cargo tanks. For smaller size vessels where a limited amount of inert gas is required a dedicated inert gas generator that burns gas oil providing clean fumes is used [5]. The clean fumes produced do not contaminate the cargo and are thus suitable for product carriers carrying sensitive products. On LRI and LRII vessels a dedicated inert gas generator is normally not installed as the big quantities of gas oil required for inerting make its use uneconomical. On crude oil tankers the exhaust fumes of the boiler are used for ‘inerting’ (flue gas), and are led to the tanks after passing through a scrubber installation for cooling and cleaning [6]. Similar arrangements are used on LRI and LRII vessels, the difference being that better cleanliness of the fuel is ensured by passing the flue gas through a second scrubber installation.

Structurally, corrugated longitudinal and transverse bulkheads with upper and lower stools have been successfully used in smaller vessel designs. This arrangement assists the tank cleaning operations and in many cases the longitudinal stiffeners are also placed on deck, rendering operation-friendly flat surfaces in the tanks that are easily cleaned for switching between cargoes. Longitudinal corrugated bulkheads do not contribute to the longitudinal strength of the vessel and the above design cannot be applied for larger vessels. As every vessel is unique and a number of different designs exist, the above should not be considered as a rule but rather as a general trend of the general characteristics of different types of tankers.

## 5.3 Cargo Background

The primary usage of aviation fuel is for powering aircraft. It is, however, used in other sectors of the industry, such as a hydraulic fluid in engine control systems and as a coolant in certain fuel system components. As this fuel is intended for a zero tolerance industry, its stability and cleanliness in every step of its lifecycle is paramount. A stable fuel is a fuel whose properties remain unchanged. Factors that can lead to deleterious changes in fuel properties include time (storage stability) and exposure to high temperatures in the engine (thermal stability). Storage stability is usually not a problem, because jet fuel is used within weeks or months after distillation. It is a factor for consideration, though, during transportation. Improper storage conditions may influence instability reactions that occur to a greater extent at higher ambient temperatures. Another factor of equal importance is fuel cleanliness. Cleanliness requires absence of solid particles and water from the fuel. Filter clogging and pump wear and tear is a result of fuel particulates. In addition water will not burn in the engine and will freeze at the low temperatures encountered in high altitude flights. This will in turn result in ice, which causes filters to clog and impede fuel flow. Water may also facilitate the growth of microorganisms and corrosion of various metals. Development of microorganisms (bacteria and fungi) forms solids by bio growth that is in turn likely to cause filter clogging and metal corrosion. Tank condition during transportation is thus a parameter of prime importance [7, 8].

## 5.4 Cargo Transportation

Jet fuel is normally transported from the refinery to the airport storage tank by a variety of means as illustrated in Figure 7-2.

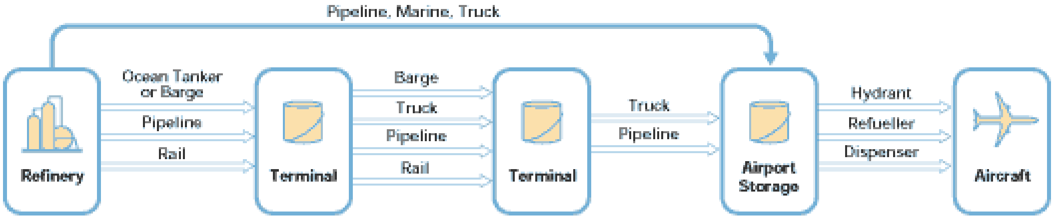



Figure 7-2

Aviation fuel means of transportation [7]

By far the most popular means of transportation of large batches of fuel is the use of pipeline. Batch shipments of a product commonly exceed 10,000 barrels making the above method of transportation the most suitable. A few refineries have dedicated pipelines for the transportation of fuel to near-by airports. Most batches of cargo, however, are transported in common carrier multi-product pipelines. Ships, barges, rail-tank trucks, tank trucks also used for jet fuel transportation are normally compartmentalized with each compartment dedicated to a certain type of product. Care must be taken to clean the compartment from previously transported residues to an acceptable level, in order to accommodate jet fuel [7].

At every stage, depending on the number of intermediate stops before the fuel reaches its final destination, quality checks are performed to safeguard against potential fuel contamination. Particulate matter and water are the most common fuel contaminants. Other petroleum products, surfactants, microbes and dye are also sources of contamination. As it is practically unavoidable for the fuel to reach its destination free of particulates and to a lesser extent free of water, various clean up techniques are in place to remove contaminants [7]. This however does not imply that safety precautions against contamination should not be enforced or relaxed at any stage of the transportation process. As for every commodity transported by sea, it is the responsibility of the master to ensure that the cargo arrives at its destination in sound condition, free of any contaminants to the satisfaction of the receiver.

## 5.5 LRII Vessel Characteristics

The LRII type vessel was developed to satisfy the need for transporting larger amounts of products. The main difference between a vessel of this type and an Aframax size crude oil carrier is the coating scheme applied. In the same manner as for smaller product carriers, coating of the cargo tanks with special epoxy paint is an important requirement ensuring the physical and chemical integrity of the high grade oil cargoes transported.

When handling petroleum products, the interaction of the cargo with certain types of material must be examined. It is said that bacteria easily breed in petroleum that is kept in bronze containers. These bacteria have the tendency to decompose the product into $CO_2$ and $H_2O$ [8]. As explained previously, for jet planes flying above 10,000 meters and being exposed to very low temperatures (minus 30~40$^{o}$C air), any traces of water will freeze, clogging the fuel supply line and interrupting supply to the engine with disastrous consequences. There is always a risk when water is produced by bacteria which remain in the fuel, that this water will not be detected and removed during normal checks. Thus, any favourable conditions for bacterial breeding should be eliminated and any extended interaction with bronze must be avoided. In the particular case of a product tanker transporting aviation fuel, the level of protection must increase. The main sources that could lead to cargo contamination are the heating coils and the casings of the cargo pumps, normally constructed of bronze [9]. On chemical tankers that use submerged pumps in their cargo tanks, stainless steel (SUS) or ductile cast iron is the material normally used for the pump casings. Bacteria, however, do not breed rapidly and it is not thought possible for them to develop in the short time that the cargo remains in the pump casing of an oil tanker with a conventional pumping system (located in the pump room). The traditional bronze pump casing has so far been normal practice on oil product tankers that do not use submersible pumps, even when they are involved in the transportation of jet fuel oil [10]. In the cargo tanks of crude oil tankers where oil may be stored for extensive periods of time Al-Br heating coils will create favourable conditions for bacteria breeding. For this reason, SUS heating coils are used on product tanker vessels [9].

Fuel contamination and cargo discoloration may also be caused during the process of inerting the tanks. An inert gas system is required on all new tankers and most existing tankers of 20,000 dwt and above. Tank inerting is the process of creating a non explosive atmosphere in the cargo tanks and minimizing the danger of fire and explosion. The amount of oxygen inside the cargo tanks, that may create an explosive mixture with the fuel gases, is controlled by replacing air with inert gas. Inert gas has low oxygen content that is not enough to form an explosive mixture. The normal method is to fill the tanks with inert gas from the ship's boiler flue mainly consisting of Nitrogen and $CO_2$. Boiler flue gas is cooled and cleaned of soot and $SO_2$ by seawater in a scrubber unit and then pumped into the remaining space of loaded or empty tanks, creating a positive pressure head [6]. However, boiler flue gas will often cause cargo contamination for sensitive cargoes. A different method should thus be used for inerting the tanks. In smaller size Chemical II/Product vessels (dwt < 35K) the concept of nitrogen blanketing of the cargo is used. On other product tankers an inert gas generator burning “cleaner” fuel (Gas Oil) is installed onboard, and the clean flue gas (that will not cause cargo contamination) is then pumped into the cargo tanks. Such an installation however would not be cost-effective for an LRII vessel, as large quantities of gas oil will be required for this purpose. Feedback from the industry suggests that for LRII vessels transporting jet fuel, flue gas that will not contaminate the cargo can be obtained if a second scrubber is installed on board, in line with the existing flue gas system scrubber [11].

## 5.6 Market Investigation

When examining the Aframax tanker world fleet make up and order book, it appears that there will be a 30 % increase in fleet size in the coming years. As shown in the figure, contracting for such vessels has increased rapidly, reflecting the current good state of the market and it’s potential. As a result of the good market, scrapping of older vessels has decreased as owners can still charter their older vessel and are willing to spend money on maintenance to take advantage of the good market.

Aframax Tankers (80-120,000 dwt tonnes)

| No. Vessels(end) | 2004 | 2005 | Oct-2006 | Orderbook | |
|---|---|---|---|---|---|
| Fleet Totals | 622 | 670 | 700 | 2006 | 14 |
| Deliveries | 52 | 65 | 39 | 2007 | 51 |
| Scrapping | 25 | 17 | 9 | 2008+ | 146 |
| Contracting | 66 | 45 | 102 | Total | 211 |
| Orderbook | 168 | 148 | 211 | % Fleet | 30.1% |
| **(m) DWT (end)** | **2004** | **2005** | **Oct-2006** | **Orderbook** | |
| Fleet Totals | 62.2 | 67.6 | 71.07 | 2006 | 1.53 |
| Deliveries | 5.6 | 7.0 | 4.27 | 2007 | 5.62 |
| Scrapping | 2.3 | 1.5 | 0.83 | 2008+ | 16.03 |
| Contracting | 7.3 | 4.9 | 11.25 | Total | 23.17 |
| Orderbook | 18.3 | 16.2 | 23.17 | % Fleet | 32.6% |

*c = Coated Tanks*

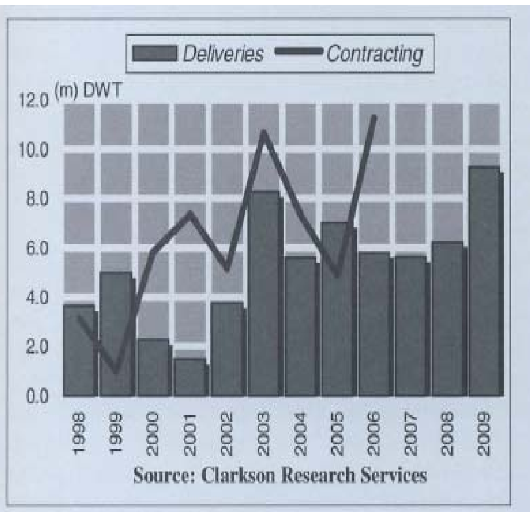



Figure 7-3

Aframax tankers world fleet make up and order book

Source: Clarkson [12]

As the owner is targeting a certain cargo i.e. jet fuel, that has to be transported in coated tanks, it would be useful to examine the number of coated vessels that will come into the market. As discussed coated vessels are the only vessels capable of carrying jet fuel. The complete set of data is presented in Appendix 4 [12]. From this it can be deducted that the number of coated vessels (product tankers) currently on order is 47 representing 22% of the total Aframax vessel currently on order.

The amount of seaborne trade up to this date is presented in the diagram below (Figure 7-4). It is evident that the crude oil trade has been increasing steadily since 1985, while the oil products trade has increased but at a smaller rate.

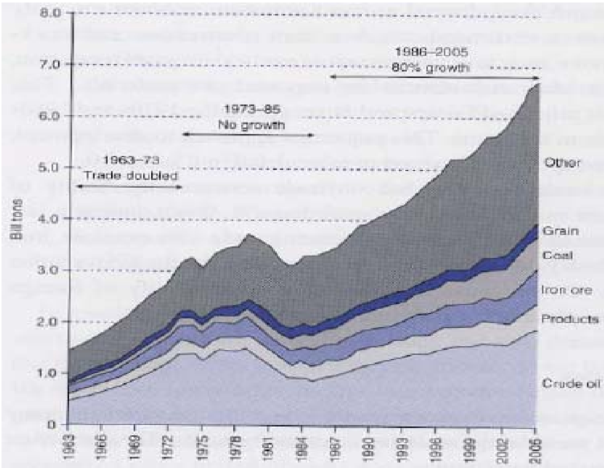



Figure 7-4

Oil product imports 1963-2007 and major seaborne trade by commodity1963-2005

Source: Fearnleys Review [13]

In the shipping industry, oil products have been traditionally transported mainly via small product/chemical tankers. The development of new refineries capable of producing high grades of oil products located in the producing areas is creating a new reality [14]. The increasing haul of commodities can be seen in Figure 7-5 were the average haul miles for oil products are seen to be increasing. Moreover a major change can be seen in oil product imports (Figure 7-6) in the 1980s when the ‘other countries’ imports started to grow rapidly quadrupling from 75mt in 1984 to 309mt in 2006. The split of the 2005 trade in Figure 7-6 shows that Asia accounts for two-thirds of this trade, in particular China, Korea and the many growing Asian economies which have a shortfall of certain product types [1].


Figure 7-5

Average haul of commodity trades 1963-2005

Source: Fearnleys Review [13]

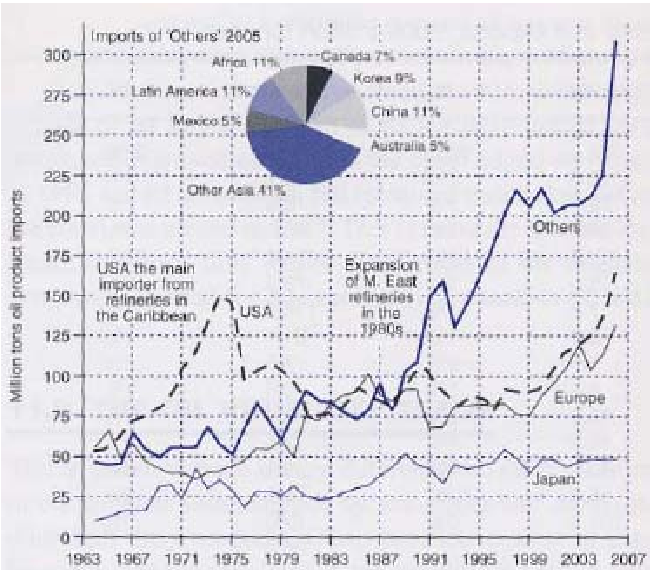



Figure 7-6

Oil product imports 1963-2006

Source: BP, Statistical Review [15]

Longer transport distances require economy of scale, and consequently a need for larger product carriers capable of transporting large quantities has started to emerge. As a result fully coated product carriers of greater capacity, LRI and more recently LRII vessels have been developed. Many analysts regard this as a growing market. Many owners are thus in the process of considering to target this sector of the market for future investment. Jet fuel forms a major part of this product market. Ever-growing increase in airborne traffic suggests that jet fuel is and will continue to be a very popular commodity, resulting in the increase of number and size of batches transported.

For an Aframax size tanker the cost for a new building in a Far Eastern yard comes about to US $61,500,000 (2006 data). When incorporating the special features of an LRII type vessel, the cost of the project rises to about US $64,000,000 [16]. With the ongoing new building activity at the time, and considering that all slots of reputable yards for delivering a vessel within the near future are booked, delivery of such a vessel is not possible, even in the best of cases, within a three year period [12]. As discussed the trend for product tankers of this size is relatively new and not many of them currently operate in the market, so the option of acquiring an existing vessel is also limited. The conversion of an existing vessel is thus investigated.

## 5.7 Key Requirements and Market Factors to Consider

Based on the above, when considering converting to an LII vessel intended to transport jet fuel the following should be kept in mind;

1. The cargo tanks should be painted with special epoxy paint.
2. The cargo tanks heating coils should not be made out of bronze.
3. The inert gas used should not contaminate the fuel.
4. A quarter of the Aframax vessels currently on order are LRII type.
5. Jet fuel transportation is an up and growing market.

## 5.8 The Candidate Vessel

As the owner envisages that jet fuel transportation over long ranges will prove to be a field of increased commercial activity in the near future and for some time to come, he decides to investigate the possibility of converting one of the youngest vessels in his fleet. This is an Aframax crude oil carrier delivered January 2003, complying with all latest regulations. Because of the vessel's age it will not require any major repair and maintenance work. The direct costs involved will be conversion related expenses. Details of the vessel are presented in Table 3.

| **Vessel for Conversion** | |
|---|---|
| Vessel name | Roxy Music |
| Flag | Bolivian |
| Type | Aframax size crude oil carrier |
| Year of built / yard | January 2003 / HHI |
| Dwt / draught | 105,000 tonnes /14.3 m |
| Length/ beam | 249 m / 43 m |
| Number of tanks | 12 tanks with centre line bulkhead |
| Cubic capacity of tanks 100% | 125,203 $m^3$ |
| Cargo pumps | 2,500 $m^3$/h bronze casing Shinko pumps |
| Cargo features | Three grades / coiled Al-Br |
| Cargo tank under-deck, tank top | Painted – coal tar epoxy |
| Main engine | MAN B&W -19100 kW |
| Inert gas system | Standard flue gas system |

Table 7-3

The vessel is currently operating under a Time Charter with returns of $27,000/day.

## 5.9 Major Conversion Investigation

LRII vessels will be classed as Oil Carriers (ABS Notation) vessels designed and constructed primarily for the transportation of petroleum products (crude oil) in bulk, having flash points at or below 60$^{o}$C. There is no specific notation to indicate that the tanks of an LRII vessel are coated and suitable for carrying certain petroleum products such as jet fuel. [17]This is a commercial advantage of an LRII vessel when compared to an Aframax crude oil carrier. The notation of the ship will not change and neither will the ship type so the conversion is not classed as “major”.

## 5.10 Conversion Design

In order to make a first estimation of the conversion costs involved the scope of work should be determined. As described above, the main difference between an Aframax crude oil carrier and an LRII vessel is the coating of the cargo holds. This will be the major cost item. The main technical elements of the conversion are presented below:

***Tank cleaning***

After the last discharge and before entering the yard the vessel’s crew must proceed with tank cleaning. Crude oil washing will take place as during normal operations, while the cargo is being discharged. Sea water cleaning and further cleaning using hot fresh water, detergent and special chemicals will then have to take place using the vessel’s tank cleaning machines. All remaining residues from the tank top will be removed preparing the vessel to enter the yard. The vessel should arrive at the yard with its tanks clean and gas free. Slops remaining on-board the vessel from the tank cleaning operation will then be received by the yard.

***Staging***

Staging of all cargo tanks is required. As painting of the entire cargo tank is required including the under deck area the complete tank will have to be staged. It is normal practice for yards nowadays to quote for staging per cubic meter. The total volume of tanks requiring staging has been calculated to be 110,000 m$^3$.

***Tanks surface cleaning in the yard***

Once the tanks of the vessel have been staged, manual cleaning (using steam and chemicals) will take place in order to remove all remaining oil traces on the tanks surfaces before they are painted. Final checking of the suitability of the surfaces before blasting takes place will be done using a black light.

***Grinding of free edges***

As during construction of the oil tanker the tanks were not intended to be painted, no grinding and equivalent surface preparation was done to the edges of the structural members of the tank. This preparation is vital and is required for the new paint to adhere to the free edge surface of the structural members. This labour intensive operation must thus be performed.

***Blasting***

Once grinding of free edges has been completed, blasting of the tanks (S.A. 2.5 standard) should take place. Blasting will include all areas of the tank plus the already painted areas of the deck-head, under-deck stiffening and tank top, which were painted during new building. For the application of pure epoxy paint a very good surface preparation (S.A.2.5 standard) is required.

***Air blow***

All dust deposited on the tank surfaces during blasting will have to be removed before the surfaces are coated. Air blowing of the tanks is thus required. This is the final step before coating of the tanks.

***Coating***

Two coats of 150 microns each pure epoxy will be applied. Two stripe coats, using brush or roller will also be applied on welding seams, on the inner side of stiffeners where spray painting is difficult, and on the newly prepared free edges.

***Replacing heating coils***

The material (Al-Br) of the heating coils is not suitable for handling jet fuel. All Al-Br heating coils in the cargo tanks will thus be replaced by stainless steel coils.

***Modifying inert gas system***

As it has been discussed, particular attention should be paid to the vessel inert gas system, as this will have to be suitable for carrying jet fuel. The vessel is currently equipped with a standard boiler flue gas system that passes through a scrubber and is then pumped into the tanks. As the installation of an inert gas generator proves to be uneconomical for a vessel of this size, a second scrubber will be installed in line with the existing one, to make the system acceptable for the carriage of jet fuel.

## 5.11 Conversion Cost and Time Estimation

Having examined the main components involved in the conversion, it is possible to make a first estimation of costs related directly to the conversion work. In Appendix 5 [18] shipyards in different geographical locations, namely; Europe (Atlantic), Europe (Black Sea), Singapore and China are compared using pilot prices for the three major cost items. As Chinese shipyards appear to have a significant cost advantage, the following table was drawn using pilot prices from previous projects in China.

| SCOPE OF WORK | UNIT | UNIT COST $ | COST $ |
|---|---|---|---|
| | | | |
| COW During Last Unloading | 0 | 0 | 0 |
| S.W. Tank Washing | 0 | 0 | 0 |
| Hot F.W. Tank Washing (20 Tonnes F.W.) | 20 | 200 | 4,000 |
| Thinner Tank Washing (5 Tonnes Thinner) | 5,000 | 2 | 10,000 |
| Detergent Tank Washing (5 Tonnes Detergent) | 5,000 | 2 | 10,000 |
| Staging 110,000 ($m^3$) | 110,000 | 3 | 330,000 |
| Manual Cleaning by Steam ($m^2$) | 64,000 | 1 | 64,000 |
| Manual Cleaning by Detergent ($m^2$) | 64,000 | 2 | 128,000 |
| Grinding of Free Edges (m Length) | 102,000 | 0.75 | 76,500 |
| Blasting 2.5 SA ($m^2$) | 64,000 | 11 | 704,000 |
| Air Blow Dust ($m^2$) | 64,000 | 0.3 | 19,200 |
| Paint 1st Coat 150 micron Pure Epoxy | 64,000 | 0.6 | 38,400 |
| Paint 2ndt Coat 150 micron Pure Epoxy | 64,000 | 0.6 | 38,400 |
| Cost of Painting Material ($m^2$) | 64,000 | 10 | 640,000 |
| 2 Stripe Coats (m Length) | 150,000 | 0.3 | 45,000 |
| Grind and Touch Up all Old Damages | 1 | 50,000 | 50,000 |
| De-staging | 1 | 0 | 0 |
| Replace A1-Br Heating Coils With SUS | 1 | 60,000 | 60,000 |
| Purchase & Installation of Second Scrubber | 1 | 200,000 | 200,000 |
| | | | |
| **Total** | | | **2,417,500** |

Table 7-5 [18]

This gives a first estimation of the total costs directly related to the conversion job of about US $2,400,000. In the above estimation cost no allowance for the conversion design cost has been made. For a conversion of this type, that does not involve extensive design work, the design cost is expected to be minimal and for the purpose of first estimation the cost can be considered to be absorbed in the above value. The time required for a conversion of this magnitude can be estimated to be 40 days.

## 5.12 Investment Analysis and Decision

In addition to the direct costs involved indirect costs will be incurred as a result of loss of earning for the period the vessel remains in the yard. The total downtime of the project will involve;

a. Time required for the actual conversion; Estimate 40 days
b. Time required for preparing the vessel to enter the yard; Estimate 8 days
c. Time required for repositioning and finding suitable cargo; Estimate 4 days

This gives a total of 52 days out of service. The nominal period, however, will be 42 days as 10 days would have been required in any case for the vessel's normal special survey. With the vessel currently under a fixed time charter with earnings of $25,000/day the downtime can be estimated as $1,050,000. Taking into consideration the actual conversion cost estimation the total project investment will amount to about $3.5 million.

Having been converted to an LRII type vessel, the owner is positive to secure a similar contract with returns of $32,000/day for a 5 year period, the increase in earning capacity thus being $5,000/day. At this rate of return the investment will be paid back (PBP) in 700 days or just about 2 years. From then on the increased charter rate will count as a profit.

The above is a crude approximation that does not take into account a number of factors such as the owner's time value for money, taxation, etc. It is considered adequate however as a first approach on the commercial viability of the conversion.

Based on the information generated through the conversion feasibility investigation process, a decision for proceeding with the conversion can be made. The conversion plan considered will satisfy the technical requirements for carrying jet fuel. The PBP for the investment appears to be about two years in which period a large number of newly built LRII type vessels will start entering the market. Transporting jet fuel in large quantities appears to be an up and growing market, however the large amounts of new-building scheduled to enter the market in the near future may cause a slowdown. If a contract can be secured for a five year period and considering the PBP, the above conversion will appear to be a viable option. Moreover, at the end of the considered time charter or in the event of a slowdown in the product market, there will be no technical restriction forbidding the vessel to switch back to the carriage of crude oil and vice-versa.

### 5.13 Conversion Specification, Yard Selection and Timing

Following the decision for conversion detailed specifications will have to be prepared, which will then be sent to candidate yards. A suitable candidate will be then selected based on the quotations received. Special consideration will also have to be paid to conversion timing.

The vessel under consideration was built in January 2003. Its first docking survey should take place during the period between its second and third annual survey. As the vessel has been accredited by class with a notation for under water survey in lieu of dry-docking, the first docking survey was granted in the form of an underwater inspection. The vessel will be required to exit the water for inspection at the anniversary of its first special survey i.e. January 2008. It would be beneficial for the owner if the conversion of the tanks could take place at the same time as the first special survey, which can actually commence August 2007, as presence in the yard will be required during that period in any case.

Shipyard related costs for the first docking survey of a vessel of this size, assuming that no major repairs are required, can amount to about $600,000 in a Chinese yard and with downtime of a 10 day period [18].

# CHAPTER 6 CASE STUDY II

## 6.1 Preamble

In this case study a regulatory conversion will be discussed. Following regulatory requirements for oil tankers of single hull type and their gradual phase out, the conversion of a single skin oil tanker into a double hull tanker is a realistic prospect [1, 2]. The period during which this investigation took place is the fourth quarter of 2006 and data from this time is used.

The regulating frame concerned with tanker oil pollution, including Annex I of MARPOL 73/78 which is dealt with in this case study, has evolved dynamically throughout the years with various amendments and additions, adapting to lessons learnt over the period and forming the face of today's oil industry [Appendix 6] [3, 4]. A brief history presenting the evolution of early day tankers to today's tankers of double skin construction is presented in Appendix 7 [3, 5].

For the purpose of this case study the following terms have been used as per MARPOL [4];
Double Hull (DH); Vessel where the entire cargo tank length is protected by ballast tanks or spaces other than cargo and fuel oil tanks as specified by regulation 13F of Annex I.
Single Hull (SH); Vessel where the entire cargo tank length is not protected by ballast tanks or spaces other than cargo and fuel oil tanks as specified by regulation 13F of Annex I.
Double Side (DS); Vessel where the sides of the entire cargo tank length are protected by ballast tanks or spaces other than cargo and fuel oil tanks.
Double Bottom (DB); Vessel where the bottom of the entire cargo tank length is protected by ballast tanks or spaces other than cargo and fuel oil tanks.

## 6.2 Scenario

An owner of a fleet of DS crude oil carriers is investigating the option of converting some vessels to DH construction in order to extend their trading certificates and comply with latest regulations. All vessels are currently operating in the Pacific basin and future plans are to continue to operate in this geographic location.

## 6.3 Background Information

### (a) Regulatory scheme applying to vessels of SH construction

Until the regulatory guidance governing the form of today's modern DH oil tankers was developed, a number of different designs were proposed and built. The majority of these designs were of SH construction having various configurations and arrangements of their ballast tanks.

According to the latest regulations for the phase out of SH oil tankers, 2010 is set as the principal cut-off date. The flag state administration however may allow for some newer SH vessels under their registry that satisfy certain technical requirements, to continue trading until the 25th anniversary of their delivery. These include vessels fitted with DB, or DS, or DH (of dimensions smaller than those dictated by Reg.13F) subject to their providing protection to the entire cargo length and that the spaces are not used for the carriage of oil [3, 6, 7].

### (b) Construction of modern double hull tankers

As per MARPOL Annex I, Regulation 13F (3) (b) for tankers of 5000 tons dwt and above, the cargo tanks of the vessels should be located at the following distance from the ship's side shell [4]:

$h = B/15$ or 2.0m whichever is less with a minimum distance of 1.0 m.

## 6.4 Aframax World Fleet – Make Up and Prospects

As has been discussed, trying to predict future market trends, demand and supply, is an uncertain process even for the most skilled analyst. Depending on the background and point of view of each person, figures and facts may be interpreted in a different way. Nevertheless, it is always important to get a feeling of the market by examining the general perspective for the sector in question. Assuming a healthy energy market for the years to come as experts predict, with an increase in ton-miles and oil dependency for the developing countries, it would be now useful to examine the make-up of the world Afra7max fleet [Appendix 8] [8].

As can be seen, great steps towards modernization of the fleet have been made in recent years with modern vessels less than 10 years of age representing 57% of the world fleet [8]. This can be attributed to the regulations for phase out of SH oil tankers that come into force, first as a requirement of OPA 90 and then as an IMO regulation [3, 9]. Furthermore, 22,986 k tonnes dwt that represent 23% of the existing world fleet will be entering the market by 2010 [8]. This will result in a growing modernized fleet. Most of these vessels are expected to be commissioned between 2008 and 2009, causing, as most analysts predict, an inevitable market slowdown during this period. The extent of this slowdown, however, is doubtful, as the principal cut-off date for SH oil tankers (2010) will be approaching which may lead a number of aged vessels to scrap [5, 7].

Examining the scrapping rates of existing vessels, one can see that owners are very reluctant to scrap their aged vessels and would rather invest in repairs and conversions choosing to retain the trading certificates, despite the very attractive scrapping rates offered. This is largely influenced by the current peak in freight rates and the low steel repair prices of Chinese yards where extensive repairs can be accommodated at a reasonable cost. Scrapping of Aframax tankers peaked in 2003, the year when the accelerated phase out scheme was brought into force, leading to a total of 41 vessels (3,701 k dwt) being decommissioned [5]. Despite this revised phase out scheme, scrapping rates were reduced during the following years as a result of the very healthy market freight rates. The possibility offered for continuation of trading in various parts of the world that did not take immediate effect of the new regulations led owners to reconsider scrapping of old vessels. It must be kept in mind, however, that the phase out scheme adopted will at some stage have an impact on current scrapping rates reducing the vessels' scrap value.

## 6.5 Area of Operation

In the case study scenario presented the entirely owned fleet of SH vessels is currently operating in the Pacific basin with future plans of keeping them in this region.

The regulation in force dictates that the implementation of the policies of MARPOL Annex I Reg. 13G & 13H is up to the flag state and country of the areas in which the vessel is trading. It is thus prudent to examine the policies of the prime trading partners in this region and evaluate whether or not a DH conversion would be advantageous having a significant impact to its trading pattern. These policies have been identified and are presented in Table 6-10 [3, 10].

| Port State | Policy |
|---|---|
| **Australia** | SH tankers can carry crude API over 25.7 until 2015 or the 25$^{th}$ anniversary of the vessel. HGO or heavy crude oil (API less than 25.7) needs DH tankers. |
| **Hong Kong** | SH tankers can carry crude API over 25.7 until 2015 or the 20$^{th}$ anniversary of the vessel. DB or DS can carry crude API over 25.7 until 2015 or the 25$^{th}$ anniversary of the vessel. HGO or heavy crude oil (API less than 25.7) needs DH tankers. |
| **India** | SH tankers can carry heavier crude API over 18.2 until 2015 or the 25$^{th}$ anniversary of the vessel. DS or DB tankers can carry HGO until 2015 or the 25$^{th}$ anniversary of the vessel. |
| **Japan** | SH tankers can carry heavy crude oils (API higher than 18.3 and lower than 25.7) until 04 April 2006. Japan SH tankers can carry crude API over 25.7 until 2015 or the 25$^{th}$ anniversary of the vessel. DS or DB tankers can carry HGO until 2015 or 25$^{th}$ anniversary of the vessel. |
| **Peoples Republic of China** | SH tankers will not be allowed to call at Chinese ports after the ships initially set phase out date in 13G (4). DS or DB vessels transporting heavy grades of oil will be allowed to call Chinese ports if they are less than 20 years old. |
| **Singapore** | SH tankers can carry heavier crude API over 18.2 until 2015 or the 25$^{th}$ anniversary of the vessel. DS or DB tankers can carry HGO until 2015 or the 25$^{th}$ anniversary of the vessel. |
| **South Korea** | DS or DB vessels can carry HGO (API less than 25.7) until 04 April 2006. Single hull tankers can carry heavy crude oils (API higher than 18.3 and lower than 25.7) until 04 April 2006. |

Table 6-1

Selected port-state policies for tanker phase out

A list of the cargos transported in the Pacific basin and their density is included in Appendix 9 [11]. Taking into account the above policies for a DS vessel delivered in 1992, an analysis is made on the impact the policies will have in Appendix 10 [3, 10]. For the above port states the following are concluded:

| Port State | Australia | Hong Kong | India | Japan | PRC | Singapore | South Korea |
|---|---|---|---|---|---|---|---|
| **Number of cargoes available** | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| **Cargoes carried until phase out date** | 44 | 44 | 60 | 60 | 60 | 60 | 44 |
| **Percentage (%)** | 73.3% | 73.3% | 100.0% | 100.0% | 100.0% | 100.0% | 73.3% |
| **Phase out date** | 2015 | 2015 | 2015 | 2015 | 2012 | 2015 | No Date |

Table 6-2

Analysis of cargoes that are affected by port state policies

Evidently in this part of the world, the DS tanker fleet can trade with the majority of cargos without being directly affected until 2012. This is the year the vessels will turn 20 years of age and will be excluded from all Chinese ports. Trading, however, will still be further permitted for the majority of cargos involved for all other areas until 2015.

It must be appreciated, however, that in the case the vessel is required to change its operating area, it may face multiple limitations in the chartering market. Moreover, it is common feeling that in the future preferential treatment will be given to true DH tonnage rather than DS/DB/SH.

## 6.6 Key Requirements and Factors to Consider

Based on the above, when considering converting a DS vessel to DH the following should be kept in mind;

1. For the vessel to be considered a DH vessel it should be converted to comply with MARPOL Annex I, Regulation 13F.
2. The world Aframax tanker fleet average age will be reduced in the coming years as the fleet is being modernized.
3. Based on current port state regulations in the Pacific basin, DS vessels can continue trading until 2015 with the majority of cargoes.

## 6.7 Candidate Vessels Arrangement and Particulars

The tank arrangement of the DS oil tankers under consideration and their main particulars are presented below. All vessel are sister ships of the same design with different year of delivery so average values for this class of vessels are given.

| | **Imabari class M/T** |
|---|---|
| **Type of ship** | Crude Oil Carrier |
| **LOA (m)** | 246.84 |
| **LBP (m)** | 235.00 |
| **Breadth (m)** | 42.00 |
| **Depth (m)** | 19.50 |
| **Draught (m)** | 13.40 |
| **Built in** | Japan |
| **Built by** | Imabari |
| **Deadweight (tonnes)** | 97,150 |
| **Gross tonnage** | 52,500 |

Table 6-3
Main particulars of DS tankers considered for conversion to DH

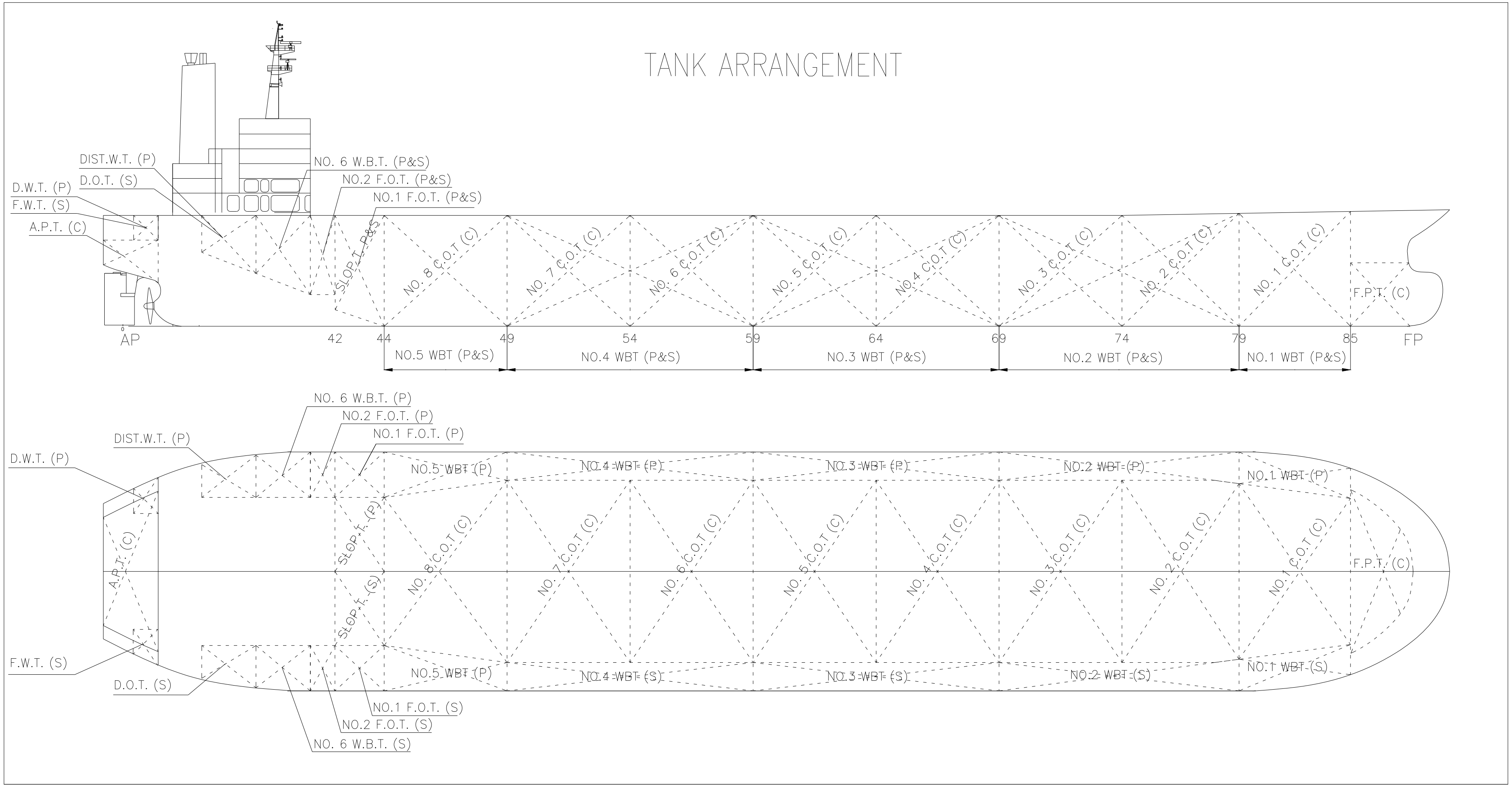



Figure 6-1

Tank arrangement of DS tankers considered for conversion to DH

## 6.8 Major Conversion Investigation

As it may appear from first sight, the above conversion falls under the category of major conversion as the carrying capacity of the ship is altered. However, according to MARPOL conversion of an oil tanker to meet regulation requirements 13 of the Annex shall not be deemed to constitute a major conversion [Appendix1]. The extent of regulation therefore will not include latest rules that apply to the construction of new buildings but will only have to satisfy DH requirements.

## 6.9 Extending Commercial Life of the Vessels without Converting to DH

As a first step, the possibility of extending the vessel's commercial value without undertaking a major conversion will be examined. By examining the tank layout of the vessels under consideration, it is easily noted that the entire cargo length, with the exception of No 1 Fuel Oil Tank (F.O.T) (P&S) in way of the slop tanks, is fully protected by ballast tanks. By converting No 1 F.O.T. (P&S) into ballast tanks, and protecting the entire cargo length, the vessels can take full advantage of the window left in the regulation which allows trading of DS oil tankers beyond 2010 until they reach their 25th year of age [3, 6]. The loss of bunker capacity can be compensated, to a certain extent, by converting No 6 Water Ballast Tank (W.B.T.) (P&S) into new No 1 F.O.T. (P&S) and vise-versa. The capacities of the new F.O.T. before and after the proposed conversion are presented below;

| **Compartment** | | **Old capacity ($m^3$)** | **New capacity after tank conversion ($m^3$)** |
|---|---|---|---|
| **No 1. F.O.T.** | P | 1,198.46 | 759.58 |
| | S | 1,198.46 | 759.58 |
| **No 2. F.O.T.** | P | 469.25 | 469.25 |
| | S | 469.25 | 469.25 |
| **TOTAL** | | 3,335.42 | 2,457.66 |
| **Loss** | | 26.3% | |

Table 6-4

Capacities of fuel oil tanks prior and after conversion

The loss of fuel oil capacity is evident and the suitability of this solution will depend on each vessel's pattern of operation. However, in most cases the above fuel oil capacities are considered to be adequate.

Another feasible option in order to satisfy the above criterion without loss of fuel oil capacity would be the installation of a longitudinal bulkhead at 2m from the side shell in No1. F.O.T. (P&S). To reinstate the lost fuel oil capacity a new tank can be created in No 6 W.B.T. (P&S) by installing a transverse bulkhead. Other combinations and solutions are also possible. However, as the work scope and complexity of the project increases so does the related downtime and cost.

As the continuation of trading depends on the policies each flag state will adopt, an uncertain factor that may change depending on circumstances, it is prudent for the owner to consider the simplest and cheapest of solutions in the case he is willing to take advantage of the above window. By doing so, for the fleet of vessels considered, the following will be the new phase out dates;

| M/T | Little Fairy | Thumbelina | Snow White | Princess | Cinderella |
|---|---|---|---|---|---|
| **Year of delivery** | 1988 | 1988 | 1989 | 1992 | 1992 |
| **Phase out** | 2010 | 2010 | 2010 | 2010 | 2010 |
| **Phase out after tank conversion ($25^{th}$ anniversary)** | 2013 | 2013 | 2014 | 2017 | 2017 |

Table 6-5

Phase-out date if the vessel is converted to DS as per MARPOL

The above conversion can easily be completed during the vessels' scheduled docking repairs. Having undertaken this task, full compliance with latest regulations is now affected only by the addition of an inner bottom in way of the cargo area. This will provide the vessel with unrestricted trading possibilities not affected by phase out dates and will be examined next.

## 6.10 Conversion Options for Compliance with Latest Regulations

A number of different designs exist for the conversion of a DS to a DH vessel with many variations that will influence the new cargo capacity. Different options, that however represent partly the number of existing options, are presented below [12].

***Option 1***

Addition of DB only as ballast tanks connected to the side tanks P&S.

***Option 2***

Addition of DB as in Option 1 and of centreline bulkhead in selected tanks, in order to minimize the free surface effect and improve the stability of the vessel making it similar to modern designs.

***Option 3***

Addition of DB as in Option 1 and inner skin in selected ballast tanks in order to increase the cargo capacity of the vessel.

***Option 4***

Addition of DB as in Option 1, inner skin in selected ballast tanks and of centreline bulkheads with connection of the new side spaces with the existing cargo tanks.

***Option 5***

Addition of a DB as a void space in order to improve stability characteristics.

When converting a DS to a DH tanker a number of technical issues have to be addressed. The addition of a DB, from a stability viewpoint in a loaded condition, will result in a higher centre of gravity, while creation of J-shaped ballast tanks through conversion will also render the vessel liable to asymmetric flooding. Further to this, the simultaneous free surface effects in the cargo and ballast tanks during loading or discharging may cause the vessel to loll. Consequently a feasibility study, including intact and damage stability calculations must be carried out before the necessary structural modifications can take place.

The study must also provide a basis for specific conversion procedures by defining a bending moment envelope. In order to satisfy MARPOL requirements, it is first necessary to define the inner hull over the entire cargo area. This may prove to be quite a challenge frequently resulting in areas of high curvature for the inner shell plating, having slope in two different planes. MARPOL requirements have been addressed in paragraph 6.3 (b). One of the fundamental questions to be answered by the designer is whether the additional longitudinal members, including plating and stiffeners, should pass through the transverse bulkhead or terminate there and be welded to them. From an engineering point of view, passing the new members through the bulkheads is obviously more difficult. However, if the longitudinal members do not pass through the transverse bulkhead they should not be counted towards the section modulus, having therefore no contribution to the vessels global strength. In larger tankers, it is usually necessary to pass the longitudinal members through the bulkhead. Once the stability criteria have been met and the new structural arrangement has been defined the feasibility study can be concluded. From there on a more detailed design study will be required [13].

In the detailed design stage a careful structural analysis needs to consider the effect that modified ballast tanks will have on scantlings. Particular attention should be paid to the boundaries of the cargo area in the aft and fore body sections. Abrupt interruption of longitudinal members needs to be avoided, as members terminating abruptly cannot be considered in the section modulus calculation. Following the conversion an inclining experiment needs to be performed based on which new load-line certificates will be issued. A converted ship will need to have its loading manual and its trim and stability book updated, while its capacity plan will also need to be revised along with tank calibration tables. A new tonnage certificate will also be issued, while schematic drawings of the pumping, piping and tank venting systems need to be submitted for approval. Modifications will be also required on the deck arrangement plans and on a number of structural drawings, reflecting the structural modifications that have taken place. In addition, the oil discharge and monitoring (ODM) and crude oil washing (COW) manuals need to be updated in accordance with the new structural arrangements. Furthermore the new ballast tanks must be coated according to IMO requirements [13].

The cost of a feasibility study of this kind is estimated to be about $5,000. This amount is small compared to the final estimated conversion cost and is not accounted for. If however a decision to proceed with a conversion is taken and detailed designs are required, these will form a considerable part of the conversion cost. For the purpose of this case study detailed designs are estimated to cost $100,000 and are accounted for as part of the conversion cost. This cost includes drawings up to class and flag approval of the conversion, and does not include workshop drawings which are produced by the shipyard and form part of the steel cost quoted [14].

## 6.11 Analysis of Each Conversion Option

***Option 1***

The addition of a DB only is the simplest of options and the minimum requirement for the vessel to be converted to fully DH. In order to satisfy the requirements, a new tank top should be fitted at a minimum distance of 2.0m from the outer shell. By adding the double bottom at this distance the cargo oil tank capacity of the vessel will be reduced by about 10.7% as follows;

| Compartment | | Old capacity ($m^3$) | New capacity ($m^3$) |
|---|---|---|---|
| **No 1. Cargo oil tank** | C | 9,752.1 | 8,644.7 |
| **No 2. Cargo oil tank** | C | 13,587.4 | 12,106.7 |
| **No 3. Cargo oil tank** | C | 14,345.5 | 12,938.8 |
| **No 4. Cargo oil tank** | C | 14,345.5 | 12,938.8 |
| **No 5. Cargo oil tank** | C | 14,345.5 | 12,938.8 |
| **No 6. Cargo oil tank** | C | 14,345.5 | 12,938.8 |
| **No 7. Cargo oil tank** | C | 14,345.4 | 12,907.0 |
| **No 8. Cargo oil tank** | C | 12,032.6 | 10,734.9 |
| **Slop tank** | P | 1.856.5 | 1,387.7 |
| | S | 1,856.5 | 1,387.7 |
| **Total** | | 110,813 | 98,923.9 |
| **Loss** | | 10.7% | |

Table 6-6

Cargo tank capacities after addition of DB

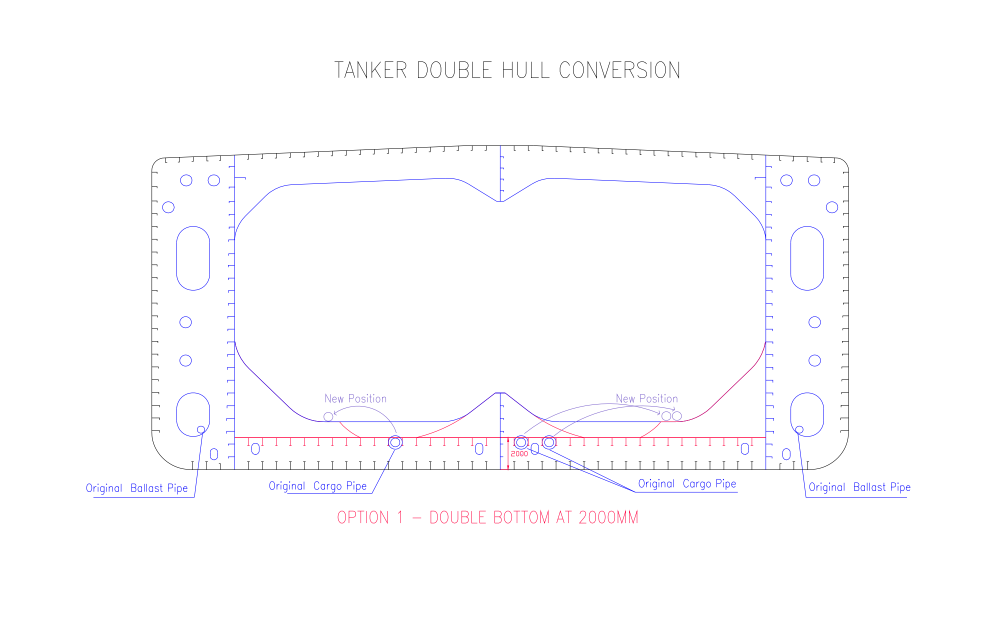



Figure 6-2

Addition of DB

The steel required for this option has been estimated to be around 1300 tonnes [12].

***Option 2***

By adding a DB to the vessel and converting it into water ballast tank the free surface moments of the vessel are increased. During loading and discharge operations, there comes a time when free surfaces exist both in the cargo and/or ballast tanks. This may result in reduced stability for the vessel. Particular attention should be paid to this by the crew and in most cases loading and discharge sequences to be followed exist in the loading and discharge manual. The above is particularly evident in early designs of DH tankers where centreline bulkheads are also absent from the tanks. For modern designs the above is covered by MARPOL Reg. 25A. No requirement, however, exists for ships in service before the ratification of the above regulation. In order to eliminate this problem a centreline bulkhead can be added in the cargo tanks. For the above design it has been estimated that five centreline bulkheads are adequate to eliminate free surface related stability problems [12]. The addition of the bulkheads will not compromise the capacity of the tanks, although some extra piping modifications will be required as the number of independent cargo oil tanks increases. An extra advantage for this option is that increased compartmentation will reduce the amount of oil spillage in the case of a cargo tank breach.

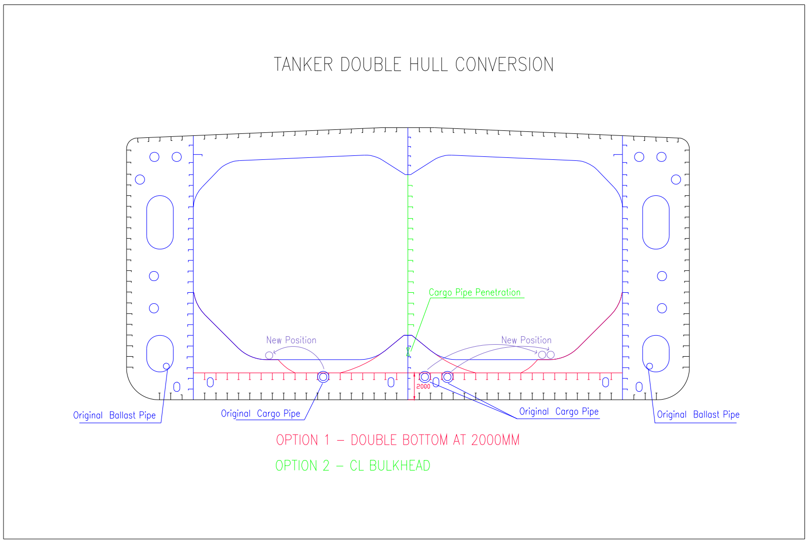



Figure 6-3

Addition of double bottom and centreline bulkhead

The steel required for this option has been estimated to be around 1600 tonnes [12].

***Option 3***

As mentioned, with the addition of the DB the cargo oil carrying capacity of the vessel is reduced by about 10.7%. This can be translated into a major loss of earnings. In order to reduce the loss in capacity, an option is to convert a number of the existing water ballast tanks partly into cargo oil tanks. The width of the side water ballast tanks is 4.983 m. Staying in line with regulations a new longitudinal bulkhead and DB can be inserted in the ballast tank retaining the required 2.0m distance from the side shell. By adding the inner skin in three selected water ballast tanks for a cargo hold length, six new independent tanks are created increasing the cargo carrying capacity of the vessel. In order to avoid excessive sagging moments alternate tanks are considered for the conversion (No3, No5 and No7 tanks). The new cargo tank capacities will be as follows;

| **Compartment** | | **New capacity ($m^3$)** |
|---|---|---|
| **No 1. Cargo oil tank** | C | 8,644.7 |
| **No 2. Cargo oil tank** | C | 12,106.7 |
| **No 3. Cargo oil tank** | C | 12,938.8 |
| **No 3. Cargo oil tank** | P | 1,161.1 |
| **No 3. Cargo oil tank** | S | 1,161.1 |
| **No 4. Cargo oil tank** | C | 12,938.8 |
| **No 5. Cargo oil tank** | C | 12,938.8 |
| **No 5. Cargo oil tank** | P | 1,161.1 |
| **No 5. Cargo oil tank** | S | 1,161.1 |
| **No 6. Cargo oil tank** | C | 12,938.8 |
| **No 7. Cargo oil tank** | C | 12,907.0 |
| **No 7. Cargo oil tank** | P | 1,142.7 |
| **No 7. Cargo oil tank** | S | 1,142.7 |
| **No 8. Cargo oil tank** | C | 10,734.9 |
| **Slop tank** | P | 1,387.7 |
| | S | 1,387.7 |
| **Total** | | 105,853.7 |
| **Before conversion** | | 110,813.0 |
| **Loss** | | 4.5% |

Table 6-7

Cargo capacities after addition of DB and inner skin in selected ballast tanks

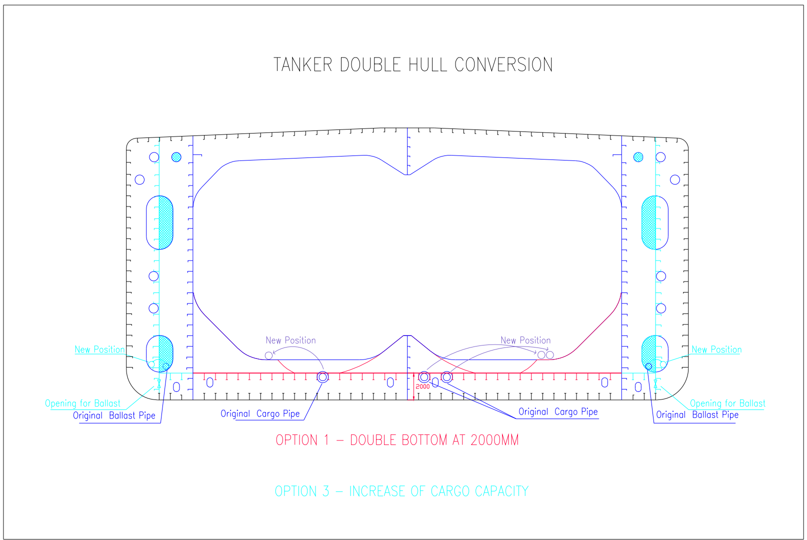



Figure 6-4

Addition of double bottom and inner skin in selected ballast tanks

The steel required for this option has been estimated to be around 1900 tonnes [12].

***Option 4***

As for Option 2 a centreline bulkhead is added in the cargo tanks to improve the stability characteristics of the vessel. By doing so, the new tanks created with the addition of the inner skin can be incorporated as an extension of the existing cargo oil tanks simply by making openings on the existing longitudinal bulkhead. This will reduce the scope for piping modifications required.

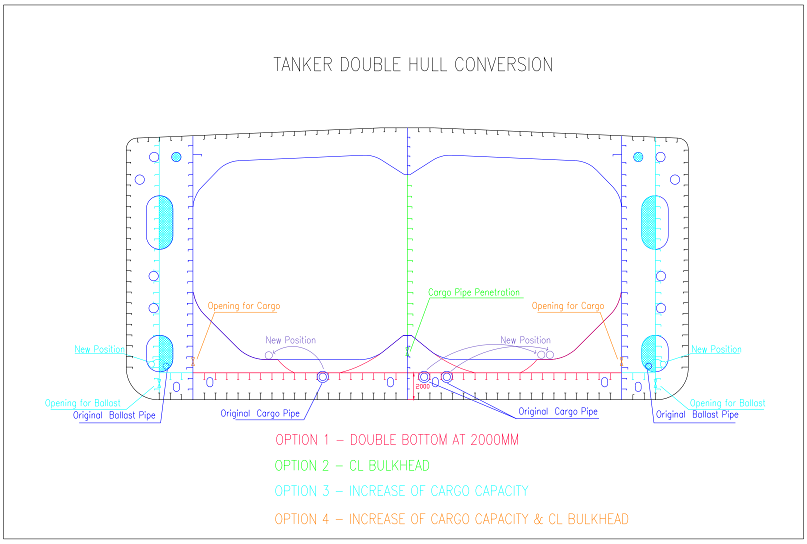



Figure 6-5

Addition of double bottom, inner skin in selected ballast tanks, and of centreline bulkheads with connection of the new side spaces with the existing cargo tanks.

The steel required for this option has been estimated to be around 2300 tonnes [12].

In the case of inner skin installation *(options 3 & 4)*, new Crude Oil Washing machines will have to be supplied for the extended cargo tanks. As the breadth of the new tanks is limited (2.983 m), cleaning of the tanks may prove to be a laborious and complicated procedure.

***Option 5***

Options 2 and 4 require the installation of a centreline bulkhead in a number of cargo tanks in order to improve the stability of the vessel. The free surface of the tanks can also be reduced, if the new double bottom tanks are converted into void spaces instead of ballast tanks. By adopting this solution, however, permanent means of access will have to be provided to these tanks which will have the form of a trunk in the existing ballast tanks. The steel work for this option is estimated to be around 1350 tonnes [12].

## 6.12 Consideration of Proposed Options

Option 1, which considers the addition of a DB only as a ballast tank, appears to be the simplest of options, although operational stability is left doubtful. Options 2 and 4 which consider the addition of a centreline bulkhead solve this concern. As mentioned previously however, current regulations do not require vessels of this age group to comply with regulation 25A covering operational stability. Discussion at the time with most “oil majors” have so far indicated that no discrimination will be made against ships not compliant with regulation 25A, as long as they meet full class rules [15]. This however cannot be taken as granted as “oil majors” and charterers may at any given time reconsider their policies [16]. There is always a possibility, in the future and in weaker markets, that this discrimination against this type of vessels may become standard across all charterers. Summarizing, this feature will have an impact on the conversion final cost and schedule, offers no significant advantage at the time, but may be critical in the future.

Since Option 5 does not present this kind of problems and the desired effect can be accomplished simply by converting the DB tanks into void spaces, it is prudent to consider this option instead. *[Option 5 will be referred to from now as Option A*]

Due to the high loss in capacity, special consideration should be given to the option of making up for it by partly converting the existing side water ballast tanks into cargo tanks *(option 3)*. In this case the new DB will have to be converted into ballast tanks to make up for the lost capacity of ballast in the wing tanks, rising again however the stability question. This option will also be considered. *[Option 3 will be referred to from now as Option B*]

Options A and B will be further considered.

## 6.13 Cost Estimation for Considered Conversion Options

Having identified the most appropriate of options, cost estimations can be made for each design. As the above project will involve major steel and sandblasting operations, Chinese shipyards appear to be the best, if not the only, candidates that can undertake the project in a cost effective manner. By identifying the major conversion works and using going rates “per unit item” of Chinese shipyards at the time, a budget can be drawn for each conversion option. The detailed scope of work and cost estimation is presented in Appendix 11 [17]. Costs for each option have been estimated as follows;

| **Option** | **A** | **B** |
|---|---|---|
| **Cost $** | 3,448,680 | 4,747,640 |

Table 6-8

Cost estimation for option A & B

It must be borne in mind that the above are only conversion costs and do not include costs involved in the related vessels dry-dock and possible life extension. These will be examined next.

## 6.14 Vessel Selection

### (a) Candidate vessels

From the candidate vessels the youngest of sisters were delivered in 1992 and the oldest in 1988. If the conversion option for extending the commercial life of the vessels to 25 years is chosen, the phase out date for the vessels ranges between the years 2013 and 2017. This of course will depend, as explained earlier, on the policies of flag state at the time. In the event of a market slowdown, preferential treatment will be shown evidently by charterers to existing DH and younger vessels excluding old vessels of SH construction. Even in the case of DH construction oil tankers, charterers often seem quite reluctant to charter vessels that have passed their 25$^{th}$ anniversary, if other available options exist. Moreover, as illustrated in Appendix 12 [5], the life expectancy of oil tankers of this size is 24.3 years. As it is not the intention to convert the entire fleet, it makes sense to the owner to go ahead with the conversion of one of the youngest vessels, namely ***Princess*** or ***Cinderella***.

### (b) Candidate background

As has been highlighted, both vessels are sister ships with a delivery anniversary of a couple of months difference. For the purpose of illustration a scenario will be built on the condition of the vessels.

***Construction***

Both vessels were built at the same yard for the same owner with the same specification. While a considerable standard has been achieved with machinery using reputable Japanese makers and tested designs that have not caused any serious problems during their operation, the same does not apply for the labour intensive hull construction. High tensile steel has been used throughout, resulting in a hull of reduced lightship and scantlings, while no proper edge preparation was made for the application of paint. In addition paint thicknesses in the ballast tanks have been kept to a minimum (150 microns & no stripe coats), with deck heads, under deck stiffening and the tank top of the cargo tanks left uncoated (the impact of having uncoated tanks has been discussed in Case Study I ). By design, it is highly impractical to perform voyage maintenance work in the ballast tanks of this kind of vessel, leaving any upgrading to be attended to only during dry-dock.

***Operation***

***Cinderella*** has operated for most of its life in the Atlantic basin, mainly transporting high sulphur crudes from South America to northern Europe, and was transferred to the Pacific basin only for the last few voyages. The aggressive nature of the cargo has resulted in a uniform sulphuric corrosion of the deck head and under deck stiffening which in many cases approaches the class-required substantial limit. As from the second special survey of the vessel, extensive paint break down has been evident in the ballast tanks. Due to the unavailability of yards offering competitive rates for addressing this problem in the vessel’s previous area of operation, the tanks have been left unattended with plans to address the problem once the “fair” class standard has been reached. Moreover due to the severe weather conditions of the North Atlantic, fatigue problems, which would normally be expected to surface at a later stage of the vessels life, are starting to appear. All the above concur that a considerable investment is required, involving major steelwork, blasting and painting works, at the vessel’s next scheduled dry-docking in order to keep her running.

***Princess*** has been operating mainly in the Pacific basin carrying light crudes with low sulphur content. As a result no sulphuric-related corrosion is evident in the cargo tanks. Similarly to the sister ship paint break down started appearing in the ballast tanks at an early age. Due to the positioning of the vessel in the Far East, however, there were a number of price-competitive labour-intensive yards easily accessible, and this has allowed the vessel to address the above problem by undertaking major paint upgrading works. All her tank painting is currently rated as good and touch-up work is planned for the next dry-docking. Although no serious fatigue problems have started to appear, several fatigue brackets were installed when the paint upgrading work was undertaken following a preventative fatigue analysis study.

The operational background of the vessel has left them in very different conditions. As pointed out, in conjunction with the conversion-related costs a major investment will be required for the ***Cinderella*** for life extension. For the ***Princess*** on the other hand, the extra cost should not exceed much the cost involved in a normal docking.

As both vessels will have to remain in the yard for an extended period for the conversion, the life extension program can be undertaken at the same time without any impact on the vessels conversion schedule.

## 6.15 Cost Estimation for Life Extension

The life extension work scope and cost involved in each case may influence the selection of the candidate vessel and may prove to be a deciding factor for the realisation of the project.

By identifying the major items involved and using “per unit item” rates, a budget can be drawn. The detailed scope of work for each vessel is presented in Appendix 13 [17]. The life extension cost for each vessel has been estimated as shown in Table 6-9.

| M/T | Princess | Cinderella |
|---|---|---|
| **Dry-docking cost $** | 616,400 | 2,402,100 |

Table 6-9
Life-extension cost estimation

The cost difference involved in the life extension of each vessel is substantial, and is attributed to their different operational background. Independent of the decision for conversion or not, the $2.4 million required for upgrading the ***Cinderella*** will have to be spent in order for the vessel to retain its trading certificates.

It must be pointed out that it is up to the discretion of the owner which items will be budgeted as life extension items and which will form part of the normal dry-docking budget. As the case study involves the conversion of the vessel to DH, it has been decided to treat all items that will improve the structural integrity of the vessels hull as life extension items. All other costs are covered as normal docking costs.

## 6.16 Cost Estimation for Normal Docking Works

The conversion will be scheduled to coincide with a special or intermediate docking survey. The estimation for the dry-docking related works for both vessels has been included in Appendix 14 [17, 18]. As before, the figures for the estimation have been based on the experience of previous dry-dockings. In the absence of such experience a specification would have to be drawn and sent to the yards which would then return with a detailed quotation. The normal docking cost for each vessel has been estimated as shown in Table 6-10.

| M/T | Princess | Cinderella |
|---|---|---|
| Dry-docking cost $ | 968,108 | 982,608 |

Table 6-10

Normal dry-docking cost for each vessel

## 6.17 Overall Cost & Time Estimation

Using the above data an overall cost estimation can be made for both vessels.

| | M/T Princess | | M/T Cinderella | |
|---|---|---|---|---|
| **Main Items** | **Estimation $** | **Round up $** | **Estimation $** | **Round up $** |
| **Dry-docking** | 968,108 | | 982,608 | |
| **Repairs independent of conversion** | 616,400 | | 2,402,100 | |
| **Design cost** | 100,000 | | 100,000 | |
| **Option A** | 3,448,680 | | 3,448,680 | |
| **Option B** | 4,747,640 | | 4,582,440 | |
| **TOTAL Life extension** | 1,584,508 | 1,600,000 | 3,384,708 | 3,400,000 |
| **TOTAL Option A** | 5,133,188 | 5,150,000 | 6,933,388 | 6,950,000 |
| **TOTAL Option B** | 6,432,148 | 6,450,000 | 8,067,148 | 8,050,000 |

Table 6-11

Conversion cost estimation

Note: The figure indicating the cost for Option B side tanks is smaller for the ***Cinderella*** because a number of blasting and painting items have already been covered in the section for 'repairs independent of conversion'.

For the above conversion and repair work scope, it is reasonable to estimate the following periods for each of the main items considered. This estimate is based on existing knowledge for similar projects that have taken place in various yards.

- 120 days assumed for the addition of a DB;
- 150 days for a DB and three side tanks; and
- 75 days for the ***Cinderella*** life extension.

## 6.18 Investment Analysis and Decision

In the following section an investment analysis of the conversion considered takes place. The analysis begins with a simple check of the PBP required to recover the investment cost. This check will indicate if investment for each option will be paid back within the vessels commercial life and hence if each conversion option can be further considered. It will not provide however any ground for comparison of the commercial value of each option and the fact that the vessels can still operate with certain restrictions until 25$^{th}$ anniversary. Its application in this case is thus limited. For a broader look at the conversion and for comparison between the available options a more detailed conversion analysis using a different measure or merit should be performed. Having satisfied key requirements and knowing the new technical characteristics of the vessels following the conversion study, the competiveness of the vessel in the market environment can now be evaluated. The pros and cons of going ahead with a conversion at this date and stage should be examined. Moreover the capabilities of the converted vessel in comparison to modern age ships and related returns should be investigated.

### 6.18.1 PBP Evaluation

As a first economic check of the investment, the PBP for each conversion option can be evaluated. Based on current charter rates of 25,000$/day for Aframax size crude oil tankers the investment for each option will paid back in the following period.

| | M/T Princess | | M/T Cinderella | |
|---|---|---|---|---|
| | **Option A** | **Option B** | **Option A** | **Option B** |
| **TOTAL Cost + Downtime** | 8,150,000 | 8,900,000 | 9,950,000 | 10,700,000 |
| **PBP (days)** | 326 | 356 | 398 | 428 |

Table 6-10

PBP for each Conversion Option

### 6.18.2 Comparison of Converted Vessel with Modern Vessels

According to its definition an Aframax tanker is a vessel of 70,000-120,000 dwt. Most new builds of modern Aframax tankers are however in the region between 105-115,000 dwt depending on the building yard. Current design trends and sizes of this type of vessel as produced from major shipyards are presented below [19].

| **Current Aframax design trends** | | | | | | |
|---|---|---|---|---|---|---|
| **Shipyard** | **M/T** | **Year** | **LOA (m)** | **Beam (m)** | **Dwt (tonnes)** | **Cubic's 100% ($m^3$)** |
| Asakawa | Americas Spirit | 2003 | 256.17 | 44.84 | 111,920 | 128,697 |
| Daewoo | Everest Spirit | 2004 | 249.9 | 44 | 115,047 | 126,918 |
| Daewoo | Phoenix Alpha | 2003 | 248.99 | 43 | 104,707 | 120,323 |
| Fincatieri | Framura | 2004 | 233 | 42 | 94,225 | 101,854 |
| Hyundai | Aegean Spirit | 2002 | 249.97 | 44 | 112,679 | 126,735 |
| Hyundai | Ceram Sea | 2004 | 248 | 43 | 105,650 | |
| Hyundai Samho | Overseas Cathy | 2004 | 238.99 | 44 | 112,000 | 130,170 |
| Imabari Saijo | Parthenon | 2003 | 246.8 | 42 | 107,181 | 119,855 |
| Imabari Shipbuilding | Eagle Tacoma | 2002 | 235 | 42 | 107,123 | 119,024 |
| Koyo | Amba Bhavanee | 2003 | 235 | 42 | 107,081 | 122,775 |
| Namura | Lita | 2002 | 232 | 42 | 118,002 | 118,002 |
| Samho Heavy Industries | Overseas Sophie | 2003 | 239 | 44 | 112,045 | 130,170 |
| Samsung | Axel Spirit | 2004 | 249.85 | 43.78 | 115,392 | 128,029 |
| Shanghai W. Shipbuilding | Corcovado | 2005 | 243.8 | 42 | 104,635 | 120,485 |
| Sumitomo | Sea Lady | 2003 | 239 | 42 | 105,611 | |
| Tsuneishi | Fuji Spirit | 2003 | 240.5 | 42 | 106,360 | 119,062 |

Table 6-14.

Modern Aframax vessel design trend

Information from charterers of Aframax size vessels suggests the following as the desirable characteristics for this type of vessels, in order of preference [15]:

1. 44m beam/ dwt 112-115,000 tonnes/ minimum 800,000 bbls/ draught less than 15m
2. 42m beam/ dwt 105,000 tonnes/ about 750,000 bbls/ draught less than 15m. Generally competes with the 44m beam Aframax without being penalized.
3. 42m beam/ dwt 95,000 tonnes/ about 660,000 bbls. Currently viable with many charterers still able to utilize this size of vessel. In the future, may no longer provide charterers' needed flexibility.

The principal carrying characteristics of the converted vessels for the two options considered are presented below.

| **As Built** | | | **Option A** | | | **Option B** | | |
|---|---|---|---|---|---|---|---|---|
| Cubic's 100% ($m^3$) | Cubic's 98% ($m^3$) | Dwt (tonnes) | Cubic's 100%($m^3$) | Cubic's 98%($m^3$) | Dwt (tonnes) | Cubic's 100%($m^3$) | Cubic's 98%($m^3$) | Dwt (tonnes) |
| 110,813 | 108,597 | 97,019 | 98,924 | 96,945 | 95,669 | 105,813 | 103,697 | 95,119 |

Table 6-15

Principal carrying characteristics for option A&B

Note: As the difference between the dwt of the two sister vessels is small, the dwt of the ***Princess*** is assumed for both in the above table.

Evidently after conversion, regardless of the option followed, the vessel will marginally satisfy the requirements of the third category (660,000 bbls ~105,000 $m^3$).

It is normal trade practice for parcels of oil cargos to come in standard stem sizes. At the moment the standard stem size in the Pacific basin for Aframax size tankers is in the region of 650,000 bbls (~103,350 $m^3$) +/-5% [15]. In such a case when examining option B vessel, this will be capable of handling most parcels of negative tolerance (-5%). However, priority will be given by charterers to vessels that can carry the most cargo.

### 6.18.3 Evaluation of Post Conversion Commercial Ability

#### (a) Parcel Size

A meaningful evaluation of the vessels' commercial ability after conversion can be made by examining the size of parcels in the Pacific basin and its loading capability for each type.

For a number of vessels and voyages the standard parcel size and type transported during 2006 is presented in Appendix 15 [11]. The limiting factors on the amount of cargo a tanker vessel can load are the vessels volumetric capacity for cargoes of low density and dwt for higher density cargoes. Using these parameters, an evaluation is made of the vessel's carrying capabilities for the two conversion options against its characteristics prior to conversion.

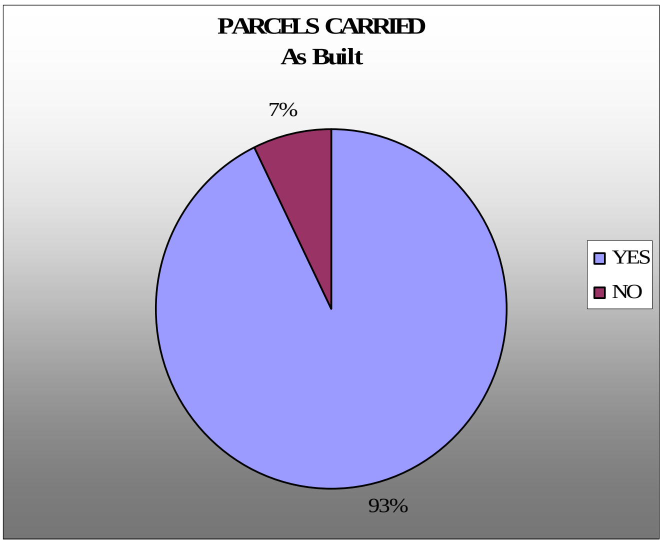



Figure 6-6.
Parcels carried prior to conversion

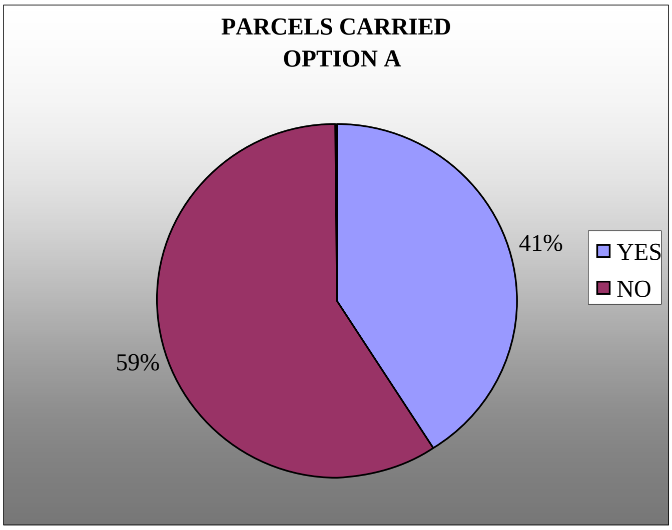



Figure 6-7.

Parcels carried with option A.

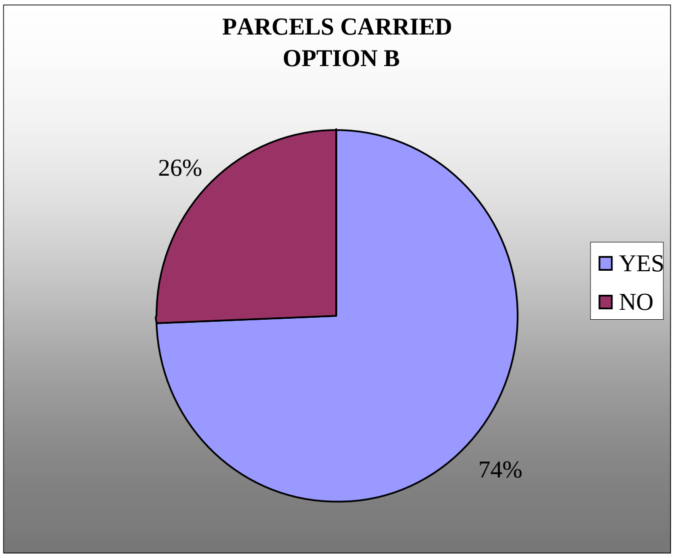



Figure 6-8.

Parcels carried with option B.

From the above analysis it is evident that, even as built, the vessel is excluded from a substantial amount of the current Aframax standard parcel sizes examined (7%). Once a DB is added, the vessel is automatically excluded as a possible candidate for the majority of parcels (59%). This percentage is improved with the addition of the three side tanks, with a quarter of the market, however, still being excluded (26%).

Moreover, further parcel limitations may exist when considering voyages to parts of the world where draught restrictions exist and where the lifting capacity of the vessel at a certain draught becomes an item of significance. This is another area of commercial disadvantage of a converted vessel.

**(b) Commercial Ability as a Pool Participant**

It is also possible to make a meaningful evaluation by examining how the vessel would perform as a member of a commercial pool. In a commercial pool all participating vessels share the pool earnings for a certain period of time, in a way which is proportional to each vessel's cargo carrying characteristics (speed, capacity etc), as well as the number of days the vessel operated in the pool (total number of days less off-hire time) which translate into a distribution key (DK) for each vessel. Therefore, the vessel's earnings in a specific period are independent of the earnings it made in the specific voyages during the period, since they depend on the average performance of the pool. The earnings are normally distributed on a quarterly basis.

The pool DK is not standard and will vary among different commercial pools depending on the agreements of the participants. In other words different DK exist for different agreements. Generally the vessel’s capabilities in each market sector are measured against benchmark voyages. These are carefully designed to take into account such factors as:

- draught restrictions;
- cargo cubic;
- speed;
- combinations and frequencies of cargo sizes and their associated stowage;
- cargo containment compatibility, cargo restriction of any type (caused by technical, legislative or operational reasons).
- port frequencies and combinations; and
- freight rates.

By assessing all the above factors for different benchmark voyages the pool DK is produced for each vessel [20].

The calculation of a pool DK falls beyond the scope of this thesis. However, for the purpose of illustration, a DK for an imaginative pool of vessels of different types and construction, including the type of vessel under consideration, is presented below.

| M/T | Type | Year | Dwt (tonnes) | Cubic's 100% ($m^3$) | Speed (knots) | Summer Draught (m) | Beam (m) | LOA (m) | Distr. Key |
|---|---|---|---|---|---|---|---|---|---|
| Hercules | SH | 1989 | 100,034 | 108,454 | 13.5 | 13.6 | 42 | 248 | 0.97442 |
| Jason | DH | 1999 | 104,707 | 120,323 | 14.5 | 13.8 | 43 | 249 | 1.04522 |
| **Cinderella** | DS | 1992 | 97,078 | 110,813 | 13.5 | 13.4 | 42 | 246.8 | **0.98382** |
| Betty Boo | DH | 2002 | 115,047 | 126,918 | 15.0 | 14.0 | 44 | 256.2 | 1.05212 |
| Cape Cod | DS | 1990 | 95,622 | 106,954 | 14.0 | 13.7 | 42 | 246.3 | 0.94442 |

Table 6-16.
DK for a pool of vessels

Once the vessel has been converted to a DH vessel its DK as a pool member will change based on the converted vessel characteristics. The main parameter that will vary after the vessel is converted to a DH vessel is the cubic capacity. As tankers are volume carriers, it is assumed that the small reduction in dwt will not influence the DK calculation. It will be assumed that capacity fluctuations influence the pool DK proportionally to a factor of 1.5 (so a 10% change in capacity of a vessel will change the distribution key by 15%). Moreover a 3% bonus is awarded on the distribution key for DH vessels. The DK changes are equally distributed to the other pool participants. In this particular case the reduction in capacity of the converted vessel causes its DK value to be reduced by 1.5 time proportional to the capacity loss. Furthermore the DK is awarded a 3% bonus increase due to the vessels conversion to DH. The change in the DK is equally distributed amongst the other pool participant's DK. The new DK for the pool participants, of both conversion options is presented below:

| M/T | Type | Year | Cubic's 100% Option A | Cubic's 100% Option B | Distribution Option A | Distribution Option B |
|---|---|---|---|---|---|---|
| Hercules | SH | 1989 | 108,454 | 108,454 | 1.007812 | 0.984048 |
| Jason | DH | 1999 | 120,323 | 120,323 | 1.078612 | 1.054848 |
| **Cinderella** | DH | 1992 | 98,923 | 105,854 | **0.850254** | **0.945309** |
| Betty Boo | DH | 2002 | 126,918 | 126,918 | 1.085512 | 1.061748 |
| Cape Cod | DS | 1990 | 106,954 | 106,954 | 0.977812 | 0.954048 |

Table 6-17.

New DK for the same pool of vessels after converting ***Cinderella*** to DH

As shown, in the case that the capacity of the vessel is reduced by 10.7% its earning capability as a member of the above commercial pool will reduce significantly by 13.6%. In the case that the capacity of the vessel is reduced by 4.5% the vessels earning capability is reduced slightly by 3.9%. Evidently the size of the investment allocated to the conversion will influence significantly its commercial value.

### 6.18.4 Present Value Method Analysis

Over a period of time, charter rates will fluctuate depending on cargo demand and vessel supply. It is virtually impossible to make future predictions with any certainty, especially for the long range. Based on the recent history of rates for Aframax type vessels operating in the Pacific basin, an investment analysis model is created in order to establish the returns of each option in Appendix 16 [21]. This model calculates the returns each option will create over its life cycle in present value terms, based on the following assumptions:

1. Charter rates remain constant over time as specified for each option.
2. Earnings of $25,000/day are assumed for the vessel if it is not converted until 2012, this figure being close to the daily average from Jan 2002-2007. Thereafter earnings of 17,000/day are assumed until 2015, being reduced mainly because the vessel is excluded from Chinese ports.
3. The above earnings of 25,000/day are adjusted for the conversion options, similarly to the pool DK adjustment examined above i.e. -14% for option 1 and -5% for option 2 and are assumed constant for the vessels life cycle.
4. Operational expenses are assumed to be at $5,000 /day and normal docking expenses at $1.5 million every 2.5 years.
5. Returns are before tax is applied
6. Next docking survey planned for 2007 (3rd special survey) conversion will take place at the same time.
7. The vessels are chartered for 300 days/year
8. Conversion downtime for each option is included in the first year as follows; 120 days required for the addition of a DB - 150 days for DB and three side tanks 75 days for ***Cinderella*** life extension.
9. Normal dry-docking downtime is included in the 300days/year assumed.

10. An interest rate of 8% is specified
11. Converted vessels are operated until their $25^{th}$ year
12. For the "No Conversion" option the modification for extending the vessels commercial life to 25 years should be completed. This is reflected as an increased docking cost in the first year.

An analysis of the investment model generates the following results:

| | Returns | |
|---|---|---|
| | **M/T Princess P.V. $** | **M/T Cinderella P.V. $** |
| **No conversion** | 29,684,057 | 26,651,649 |
| **Option A** | 24,993,404 | 23,326,737 |
| **Option B** | 27,914,057 | 26,432,575 |

Table 6-18.

Investment model analysis

The paradox with the above conversion is that, despite the increased capital investment involved, the earning ability of the vessel in terms of present value after conversion is smaller than what it was prior to it being converted. This, however, is balanced by the fact that the converted vessel will comply with the latest DH regulations and will be viable to operate worldwide, not depending on flag state phase out implementation.

As a conversion option, option B promises returns that are closer to "no conversion" returns. A technical drawback of this option was highlighted in the beginning of the case study and should not be neglected. Option B vessel will not comply with the latest MARPOL Reg.25A (instability during loading and discharging due to the presence of large free surfaces).

It must be stressed that the above investment analysis model is a simplified model created only for the purpose of illustration. Different versions of complexity will exist that may include taxation and means of financing the project. Obviously all parameters will also vary according to each investigator's experience and background, leading to entirely different results. For example, in the above model it is assumed that the converted vessels are operated until their 25th year. There is no such restricting regulation for DH tankers, and hence any operational life can be assumed.

As a matter of fact, however, there is a tendency for charterers to avoid using older vessels. Similarly a more favourable result will be achieved, if the conversions are postponed to a later date closer to the phase out date, hence taking advantage of the increased charter rates applying to the non-converted vessels. Shipyard availability closer to the phase out date however may be a considerable obstacle, as it is believed that free slots in the already congested yards will be even scarcer, leading in turn to an increased capital expenditure and downtime [22]. Results will also fluctuate considerably depending on the interest rate specified.

Finally it must be highlighted that unaccounted risks such as flag states altering their implementations policies and charterers refusing to charter single hull vessels cannot be included in the model.

## 6.19 Specifications

In the event that a decision for a certain conversion option is taken, based on the above analysis, detailed specifications identifying the areas requiring attention and including conversion, life extension and normal dry-docking items should be prepared for the vessel. The specifications should be sent to various yards that appear as serious candidates for the conversion which will then revert with their itemized cost and time quotation brake down.

# CHAPTER 7 DISCUSSION

Throughout the thesis, contributing factors in the decision making process of considering a conversion as an option have been highlighted and analyzed. The final decision will heavily depend on the information collected and the experiences of the individuals involved. A set of parameters of different significance and importance which have to be considered throughout the process from the point when a market opportunity arises and the requirement for a vessel emerges, to the final point of analyzing all data and deciding upon a conversion, have been identified. Furthermore, a rational process has been proposed for decision making. It is recognized that the methodology proposed for evaluating the viability of a conversion project is not unique, but the presentation of it as a structured process could be a useful aid that should remind those faced with assessing the viability of a proposed conversion of the complexity of the process.

In the decision making process proposed and during the stage of deciding between building a new vessel, converting, or acquiring an existing vessel the decision is made on a high level time and cost comparison. Estimates of the time and cost involved for each option are based on market information gathered. Based on this information a decision on the direction to be followed can be made. It is often the case that for certain requirements the option of acquiring an existing vessel will not exist. This appears in Case Study I and in the Jumboisation of the ***Blue Marlin*** conversion project, presented in the critical review. A similar vessel of this kind and size did not exist in the market at the time. In this case only the options of building a new or converting a vessel are considered. Furthermore, for existing vessels of a fleet at some point of their operational life conversion may appear as the only available option for them to remain competitive in their trade or even for retaining their trading certificates. In this case conversion will be considered independently from the other options as it will not appear as a result of a market opportunity but as a direct result of market research that points in this direction. This is the case for the conversion presented in Case Study II and for the Car Carrier elongation presented in the critical review. The option of converting against trading with possible handicaps or even scrapping at a close future date and the viability of conversion in the market environment is examined, before a more detailed investigation takes place.

The reason for conversion will shape to a great extent the key requirements that will further define the conversion characteristics. Based on the reason for conversion four different types of conversion and their combinations have been identified. One can argue that the categorization proposed will not cover all conversion types. It is true that in many cases the possibility of a political conversion may exist, where the conversion is heavily subsidized by the government aiming to keep a shipyard running, the labour employed or having other political aims. This, however, is a very special type of conversion the main purpose which is not to add value to the earning capacity of the ship concerned, and therefore follows an entirely different pattern of thought. Conversion targeting a specific area of operation, i.e. Arctic conditions, port limitations, canal restrictions etc, is another category that may emerge. Again it is believed that conversions of this type are already covered under the type of specialized conversions and in many cases as a combination with another category. It can thus be said that, depending on the perspective, other possible categories may appear. It is not in the intention of this thesis to cover every single conversion type or purpose. However, it is believed that in broad terms good distinctions between conversion types have been established.

It is mentioned in the methodology proposal that by directing research based on conversion type, key requirements that will influence the design can be identified and their importance assessed, forming a basis for the design process. By understanding the characteristics of the conversion type and examining them in detail the final product can be better defined in a way that it satisfies to the greatest possible extent the vessel requirement. It must be however acknowledged that while the conversion type will generate the biggest number of key requirements, a number may also be generated by research directions which are identified for other conversion types. i.e. “future forecasts” may suggest the future trend in vessel sizes, “cargo background” latest requirements for cargo transportation, “regulation” possible requirements that may affect the vessel in the near future. It is acknowledged that for the Case Studies presented key requirements have not been generated by other research directions.

Research directions for other conversion types may be considered to form part of the broader spectrum of market research. The significance and importance of market research in every stage of the conversion investigation process has to be stressed. In both Case Studies key requirements have been generated by examining future forecasts as part of broader market research. As it was also demonstrated in most of the conversion project examples examined, market research and forecasting are very significant factors in the success of the projects. The exception to this the ***Blue Marlin*** conversion which targets a specific one-off contract, not taking into account the fact that the vessel was eventually successfully used further in an expanding market. As any shipping analyst will confess, forecasting is fraught with danger. No sooner has all the data been analyzed, then either a political or natural phenomenon occurs cancelling the original forecast. Without forecasts however investments and other major strategic decisions cannot be made. Further to this, broader market research should be continuous adapting its direction depending on the new data generated throughout the conversion examination process. As the market is a dynamic entity it should be monitored continuously and should therefore shape the conversion project from concept to delivery.

As seen in the methodology proposed the conversion of a candidate vessel is expanded in two directions. The existing condition of the candidate vessel is examined in parallel with the available conversion options, as the condition of the candidate vessel will influence the conversion budget. Depending on the size of the conversion the extent by which the conversion budget will be influenced will vary and in many cases may not be considered to be significant. The size of the conversion considered and its expected lifespan have thus to be examined; i.e. when considering a multimillion dollar conversion of a single skin crude oil carrier to a Floating Production Storage and Offloading Vessel (FPSO), investing a couple of million dollars for upgrading the candidate vessel is not considered as a major cost and a candidate vessel may be selected as long as it satisfies the general physical dimensions required. To a certain extent this is also illustrated in the SUL's conversion presented in the critical review. As a new forebody would be constructed the existing condition of the candidate's vessel forebody was not important hence vastly reducing the maintenance cost involved. Particular importance during the selection of the candidate vessels would however have to be paid to the condition of the vessel’s engine room and accommodation quarters where extensive maintenance work would take place. The upgrading work in the engine room would in any case be extensive, no matter of the engine room condition, in order to satisfy the engineering requirements of the new vessel type. Eventually candidates that satisfied better the general physical dimensions required for the conversion were selected and the upgrading cost involved in each case was absorbed.

In the investment analysis and decision the PBP has been proposed as a method of assessing if the project will generate a profit within the vessel commercial life. Without doubt the PBP can often be misleading by ignoring comparative cash flows that may occur after the pay back period. It provides however clear evidence of safeguarding an investment and thus is very useful for pilot studies. From an engineering point of view it is believed that this method can provide a basis for decision making and may be complemented by other measure of merits in order to gain a better perspective if this is deemed to be required. This is the case in the investment analysis of Case Study II.

Case Study I considers a market opportunity which requires a vessel that will target a certain specialized cargo (Jet Fuel). As the transportation of large quantities of jet fuel is a fairly new trend, not many vessels of this kind exist in the market. The possibility of acquiring an existing vessel is thus limited and is excluded together with the option of ordering a new vessel at increased cost and delivery time. Examining the conversion option, the type of conversion is identified as a conversion targeting a certain cargo and research is directed in examining the characteristics and special features of the cargo in question. Forecast of future prospects is kept in mind throughout the study while applicable regulations are not examined particularly, assuming that the conversion candidate is a modern vessel complying with latest requirements. Following the investigation, and once the candidate vessel is proposed, a conversion design is drawn considering the existing condition of the vessel and the conversion requirements, which finally provides the platform for decision on a cost/time basis. More precise cost estimation can take place after the conversion specifications have been prepared and sent to a number of yards. In the final cost estimation, costs such as the conversion design cost, that has not been included in the first estimation, and costs related to supervision may be included. The level of cost estimation in Case Study I however, is considered to be adequate for assessing the magnitude of the conversion and for providing a cost decision platform. Case Study I is a good illustration of the effectiveness of the flow diagram proposed. Once background information has been gathered, and a good understanding of the target market has been established, it is possible to make an estimation of the scope of work and costs/time involved for the conversion of the candidate vessel.

In Case Study II the decision for conversion follows a change in regulation and not exactly a market opportunity that has arisen. One can argue however that the requirement for modern vessels in this sector of the market is itself a market opportunity. In any case the conversion considered falls under the regulatory conversion type. The owner examines this type of conversion in order to evaluate the future of the vessels in his fleet. Conversion examination starts by examining the extent of the regulation and applicability along with current market make up and future prospects. Based on the general characteristics of the candidate vessels a number of conversion options are proposed. These options are evaluated and the decision is made to further examine two of the most attractive options for which cost estimation is made. An allowance for the related design costs is also included in the cost estimation. The existing condition for two of the most suitable conversion candidates is then examined and cost estimation is made for the life extension of each candidate. For each conversion option and for each candidate a total time and cost figure is then obtained. The PBP method is used for a first economic check of the investment, however its use in this case is proved to be limited, showing only that each investment will be paid back within the vessels commercial life. A complete investment analysis then follows which includes market research evaluating the pros and cons of going ahead with a conversion at this date and stage, and examining capabilities of the converted vessel in comparison to modern age vessels. A different method of merit is finally used (Present Value) to lay the ground for decision making. Case Study II also appears to follow the methodology diagram proposed proving its iterative nature by considering several options and following more than one decision spiral.

As has been pointed out, when considering a conversion, there are numerous options and possibilities. Throughout the above worked examples a number of decisions and assumptions were made both in the technical and market investigation. Inevitably each and every choice will influence to a greater or lesser extent the form of the end product. As a result the final outcome of any investigation of this kind will heavily depend on the background, information and experience of the investigator. Obviously the flow diagram cannot cover in an exact manner all eventualities, which may vary case to case. However, it is believed that the proposed process for evaluating the viability of a proposed conversion is typical and must be adapted by users to suit the specific circumstances of any particular proposal. The general process of thinking towards a rational decision is well illustrated.

Finally, it needs to be pointed out that, when considering a conversion, the path each individual will follow to the final outcome will vary. The process proposed in this thesis is the general methodology of rational thinking towards a decision on a cost-time-implication basis. The exploration of applicability of the proposed methodology is by no means complete. By further examining different types of conversions that have taken place in the industry and by identifying the weight of factors that led to the final decision, a statistical approach to decision making can be established. Using feedback from the industry distinction can be made between successful and unsuccessful projects and reasons that led to the particular outcome. By doing so a better understanding of the importance of contributing factors can be established and their weight evaluated. Furthermore, for each type of conversion, critical paths can be formulated that can be used as guiding tools for future projects.

It is thought that proper analytical formulation of conversion as an option is an area that deserves to receive future research.

# CONCLUSIONS

From the work presented in the thesis the following conclusions have been reached;

1. The study shows that in the industry conversions are often selected as an alternative to building a new or acquiring an existing vessel as they are often faster and/or less costly.

2. By directing conversion research based on the conversion type key requirements that will influence the design can be easily identified. The final decision for conversion however will appear as a result of a more extensive market research and understanding.

3. The age of the vessel and its existing condition should be carefully considered before selecting a candidate for conversion. The extent to which current regulations will apply will depend on whether a conversion is considered to be major or not as defined by MARPOL.

4. By following the methodology proposed conversion can be studied in a methodical manner that will help identify and consider the factors involved.

# APPENDIX 1 CONVERSION DEFINITION

Throughout a vessel's life there is a continuum of ship support activity that runs from routine maintenance through refit and repair, upgrade and modification to alteration and conversion. According to the Oxford English Reference Dictionary the term conversion is synonymous to alteration; change in the nature form and function of something. Any alteration made to hull, machinery installations, equipment or systems of a vessel can therefore be considered as a conversion.

According to SOLAS "All ships which undergo repairs, alterations, modifications and outfitting related thereto shall continue to comply with at least the requirements previously applicable to these ships. Such ships if constructed before the date the present rule standard came into force shall, as a rule, comply with the requirements for ships constructed on or after the date to at least the same extent as they did before undergoing such repairs, alterations, modifications or outfitting. Repairs, alterations and modifications of a *major character* and outfitting related thereto shall meet the requirements for ships constructed on or after the date the present rule standard came into force in so far as the Society deems reasonable and practical."

Based on the above a vessel undergoing a conversion will not have to comply with latest rules that are applicable for new buildings unless the conversion is deemed to be *major*. A clear distinction must hence be made between modifications of *major* and *minor* character.

According to MARPOL *major conversion* means a conversion of an existing ship:

(a)

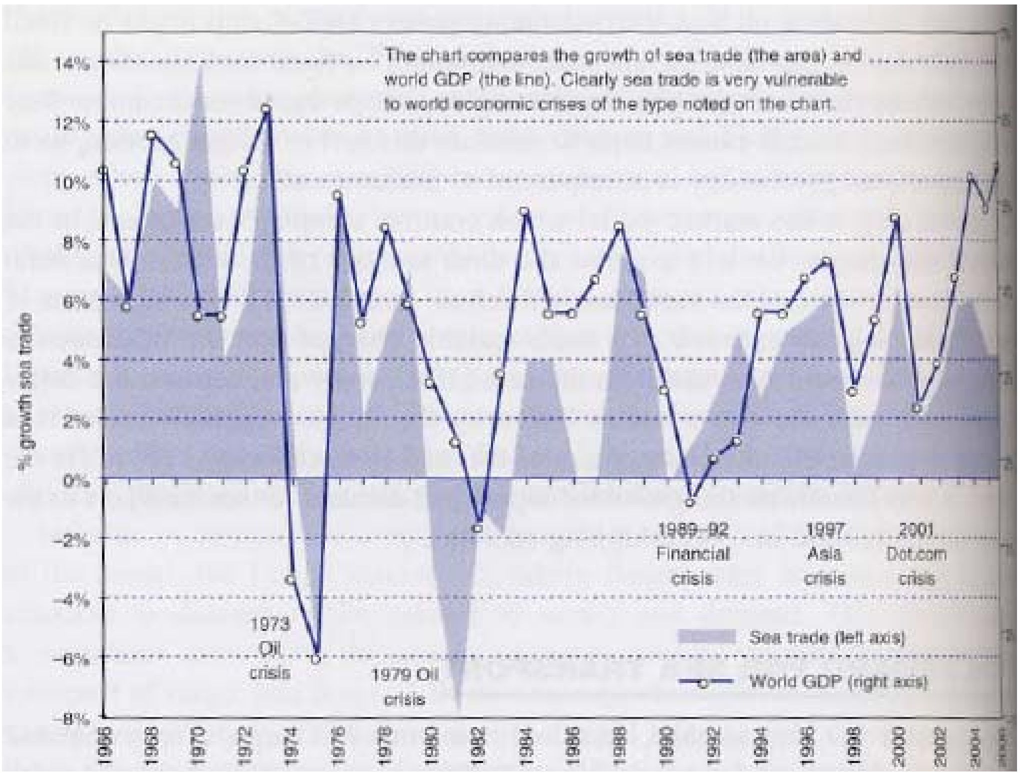
i. which substantially alters the dimensions or carrying capacity of the ship; or
ii. which changes the type of the ship; or
iii. the intent of which in the opinion of the administration is substantially to prolong its life; or
iv. which otherwise so alters the ship that, if it were a new ship, it would become subject to relevant provisions of present Convention not applicable to it as an existing ship

(b) Notwithstanding the provisions of subparagraph (a) of this paragraph, conversion of an existing oil tanker of 20,000 tons deadweight and above to meet the requirements of regulation 13 of this Annex shall not be deemed to constitute a major conversion for the purposes of this Annex.

(c) Notwithstanding the provisions of subparagraph (a) of this paragraph, conversion of an existing oil tanker of to meet the requirements of regulation 13F or 13G of this Annex shall not be deemed to constitute a major conversion for the purposes of this Annex.

Sources: 1. (1996), *The Oxford English Reference Dictionary,* Oxford University Press, Oxford 2. (2002), *MARPOL 73/78 Consolidated Edition*, IMO Publications, London 3. (2004), *SOLAS Consolidated Edition,* IMO, London.

# APPENDIX 2 WORLD GDP CYCLES AND SEA TRADE




Source: World Bank, Fearnleys Review, obtained from Martin Stopford, (1997), *Maritime Economics*, Routledge, Oxon.

# APPENDIX 3 CONTRACT GENERAL OUTLINE

I. **Definitions/ Interpretations**
This paragraph will identify and explain the meaning of “key” words included in the contract

II. **Vessel Delivery**
This paragraph will state the condition of the vessel upon delivery to the yard highlighting all required preparations to be done on board before commencement of the works. The case of late delivery due to unforeseen circumstances should be also covered.

III. **General Description of Works, Compliance with rules, Standards**
This paragraph will outline the works expected to be completed by the contractor for account of the owner. The necessity and responsibility of the contractor to perform works complying too certain rules and standards is also highlighted. The responsibility for possible design works involved will be identified.

IV. **Specific Description of each important work stage**
Each critical work stage should be separately addressed, identifying each party’s requirements and obligations.

V. **Vessel Redelivery – Acceptance Trials**
This paragraph will identify owners’ requirements for the vessel to be to his satisfaction upon redelivery at a certain date, also stating the nature and number of successful trials. Penalty clauses in the case of late or non delivery should be included.

VI. **Contract price and terms of payment**
Depending on the agreement a contract may either specify a fixed sum for the main works, or the final invoice may be calculated in the form of “as quoted” prices per item as per the specification sent to the yard. Any extra jobs not included in the specification will be added to the final invoice. The term, method and form of payment including special clauses should also be identified.

VII. **Adjustment of contract price**
A special clause for adjustment of the contract price in certain cases may exist.

VIII. **Approval of plans and drawings/ Owners Representation**
The party responsible for the approval of any plans and drawings should be clearly identified. The appointment of owner’s representatives and regulatory bodies and their rights for monitoring and inspecting the work progress, ensuring that it complies with the contract should be also stated.

**IX. Modifications**
The contract should also accommodate a chapter taking care of possible modifications to the specification, class, or other possible changes to the owners discrete.

**X. Force Majeure**
This chapter shall constitute if and to the extent that they directly give rise to the delay in the performance of work.

**XI. Warranty of Quality**
This chapter will cover possible warranties for the quality, if any, of the final project given by the builder for a certain period, including remedies offered to possible defects.

**XII. Refund of instalments**
This chapter will cover possible refunds of owners instalments in the event that the builder breeches his obligations towards the contract.

**XIII. Owners Default; Builders Default and indemnity**
This chapter will cover clauses that deem the Builder or Owner to be in default of their obligations under the contract. Indemnity clauses may also be included.

**XIV. Insurance**
This chapter will cover the owners and builders insurance obligations during the project period.

**XV. Dispute and arbitration**
In the event of a dispute an acceptable third party by both, builder and owner, should be appointed to determine the outcome.

**XVI. Right of assignment**
The right of assignment of each party will be covered in this chapter.

**XVII. Taxes and duties and compliance with laws**
This chapter will ensure that all taxes, duties and laws of the country at which the contract is fulfilled are followed by both parties.

**XVIII. Patents, trademarks copyrights**
This chapter will cover the right of each party against possible patents, trademarks and copyrights.

**XIX. Notices**
The contact details and form of communication with the persons from both sides responsible for any notices posted should be given.

**XX. Interpretation**
Forms of different interpretations related to the contract should be made clear and investigated.

**XXI. Owners supplies**
This chapter will cover items are the responsibility of the owner to supply.

**XXII. Confidentiality**
Confidentiality issues will be addressed

**XXIII. Other Issues**
This chapter will cover any other issues that the owner or yard wish to cover

**XXIV. Appendices**
Any appendices to the contract will be included here.

Sources: 1. Contract for Conversion, (2004), *Building and assembly Contract for the construction and assembly of a new forebody and attachment to the aft end of the vessel "Cabo de Hornos" between: (1) CSIC Shanhaiguan shipyard as builder and (2) hull 227 shipping inc.as owner*, Private and Confidential. 2. Contract for Repair (2005, 2006), *Repair Contract for the DD and repair of the Semakau Spirit between TK shipping and COSCO Dalian shipyard July 2005, Seletar Spirit between TK shipping and Sembawang shipyard July 2005, Seraya Spirit & Sentosa Spirit between TK shipping and MMHE September 2006, Astron Spirit between Aston Maritime and Chengxi shipyard October 2006, Compass I between OSG and Lisnave shipyard September 2005*, Private and Confidential.

# APPENDIX 4 AFRAMAX MARKET INFORMATION

## Aframax Tankers (80-120,000 dwt tonnes)

### Aframax Tankers (80-120,000 dwt tonnes)

| No. Vessels(end) | 2004 | 2005 | Oct-2006 | Orderbook | |
|---|---|---|---|---|---|
| Fleet Totals | 622 | 670 | 700 | 2006 | 14 |
| Deliveries | 52 | 65 | 39 | 2007 | 51 |
| Scrapping | 25 | 17 | 9 | 2008+ | 146 |
| Contracting | 66 | 45 | 102 | Total | 211 |
| Orderbook | 168 | 148 | 211 | % Fleet | 30.1% |

| (m) DWT (end) | 2004 | 2005 | Oct-2006 | Orderbook | |
|---|---|---|---|---|---|
| Fleet Totals | 62.2 | 67.6 | 71.07 | 2006 | 1.53 |
| Deliveries | 5.6 | 7.0 | 4.27 | 2007 | 5.62 |
| Scrapping | 2.3 | 1.5 | 0.83 | 2008+ | 16.03 |
| Contracting | 7.3 | 4.9 | 11.25 | Total | 23.17 |
| Orderbook | 18.3 | 16.2 | 23.17 | % Fleet | 32.6% |

*c = Coated Tanks*


Source: Clarkson Research Services

**2006**

| DWT | Owner | | Builder | Sched. Del. |
|---|---|---|---|---|
| 107,000 | Unknown Owner | | Imabari S.B. | Jan 2006 |
| 115,000 | Hakuyo Kisen K.K. | | Sasebo H.I. | Sep 2006 |
| 110,000 | MMS Co. Ltd | | Mitsui SB | Sep 2006 |
| 110,000 | Torm, Dampskibss | c | Dalian Shipbld. Ind. | Sep 2006 |
| 105,200 | Unknown Owner | c | Sumitomo H.I. | Sep 2006 |
| 105,000 | Teekay Shpg. Canada | c | Hyundai H.I. | Sep 2006 |
| 105,000 | Teekay Shpg. Canada | c | Hyundai H.I. | Sep 2006 |
| 115,000 | Taiheiyo Kaiun K.K. | | Sasebo H.I. | Oct 2006 |
| 115,000 | Premuda S.P.A.N. | | Samsung SB | Nov 2006 |
| 105,301 | Dorian (Hellas) S.A. | | Sumitomo H.I. | Nov 2006 |
| 115,000 | Lundqvist Rederierna | | Daewoo SB | Dec 2006 |
| 109,350 | A.P. Moller | c | Dalian Shipbld. Ind. | Dec 2006 |
| 105,200 | Samos Steamship | | Sumitomo H.I. | Dec 2006 |
| 105,000 | Valles Steamship | | Namura Zosensho | Dec 2006 |

**Total 14 Vessel(s) of 1,527,051 DWT.**

**2007**

| DWT | Owner | | Builder | Sched. Del. |
|---|---|---|---|---|
| 116,000 | Unknown Owner | | Universal S.B. | 2007 |
| 116,000 | Unknown Owner | | Universal S.B. | 2007 |
| 110,000 | Torghatten Trafikk. | c | Dalian Shipbld. Ind. | 2007 |
| 109,350 | A.P. Moller | c | Dalian Shipbld. Ind. | 2007 |
| 109,350 | A.P. Moller | c | Dalian Shipbld. Ind. | 2007 |
| 107,000 | American Eagle Tnkrs | | Koyo Dock K.K. | 2007 |
| 107,000 | American Eagle Tnkrs | | Koyo Dock K.K. | 2007 |
| 105,200 | Marubeni Corp | | Sumitomo H.I. | 2007 |
| 105,200 | Hong Kong Ming Wah | | Sumitomo H.I. | 2007 |
| 105,200 | Marubeni Corp | | Sumitomo H.I. | 2007 |
| 105,200 | Marubeni Corp | | Sumitomo H.I. | 2007 |
| 105,000 | Cardiff Marine Inc. | | Waigaoqiao S/Y | 2007 |
| 110,000 | Torm, Dampskibss | c | Dalian Shipbld. Ind. | Jan 2007 |
| 110,000 | Torm, Dampskibss | c | Dalian Shipbld. Ind. | Jan 2007 |
| 107,000 | Unknown Owner | | Namura Zosensho | Jan 2007 |
| 115,000 | ChevronTexaco Shpg. | | Samsung SB | Feb 2007 |
| 105,200 | Unknown Owner | c | Sumitomo H.I. | Feb 2007 |
| 105,000 | Teekay Shpg. Canada | | Hyundai H.I. | Feb 2007 |
| 116,000 | Interorient Nav. Co. | c | Hyundai H.I. | Mar 2007 |
| 115,000 | Yasa Shpg. Industry | | Samsung SB | Mar 2007 |
| 115,000 | Cido Shipping | | Sasebo H.I. | Mar 2007 |
| 113,000 | Viken Shipping | | Samsung SB | Mar 2007 |
| 106,000 | Bergshav A/S | | Tsuneishi Zosen | Mar 2007 |
| 105,000 | Tsakos Energy Nav. | | Sumitomo H.I. | Mar 2007 |
| 105,000 | Teekay Shpg. Canada | | Hyundai H.I. | Mar 2007 |
| 113,500 | Geden Line | | Samsung SB | Apr 2007 |
| 116,000 | Interorient Nav. Co. | c | Hyundai H.I. | May 2007 |
| 115,000 | Geden Line | | Samsung SB | May 2007 |
| 115,000 | Cido Shipping | | Sasebo H.I. | May 2007 |
| 114,670 | Ernst Jacob | | Daewoo SB | May 2007 |
| 105,200 | DSD Shipping A/S | | Sumitomo H.I. | May 2007 |
| 105,000 | Novoship (UK) Ltd. | | Hyundai H.I. | May 2007 |
| 115,000 | Cido Shipping | | Sasebo H.I. | Jun 2007 |
| 106,000 | Bergshav A/S | | Tsuneishi Zosen | Jun 2007 |
| 105,000 | Tsakos Energy Nav. | | Sumitomo H.I. | Jun 2007 |
| 115,000 | Arcadia Shipmngt. | | Samsung SB | Jul 2007 |
| 115,000 | Yasa Shpg. Industry | | Samsung SB | Jul 2007 |
| 105,000 | Novoship (UK) Ltd. | | Hyundai H.I. | Jul 2007 |
| 115,000 | Novoship (UK) Ltd. | | Samsung SB | Aug 2007 |
| 110,000 | Fratelli D'Amico | | Mitsui SB | Aug 2007 |
| 106,000 | Polyar Tankers AS | | Tsuneishi Zosen | Aug 2007 |
| 115,000 | Arcadia Shipmngt. | | Samsung SB | Sep 2007 |
| 115,000 | Cido Shipping | | Sasebo H.I. | Sep 2007 |
| 115,000 | Geden Line | | Samsung SB | Oct 2007 |
| 106,000 | Polyar Tankers AS | | Tsuneishi Zosen | Oct 2007 |
| 115,000 | Cido Shipping | | Sasebo H.I. | Nov 2007 |
| 115,000 | Novoship (UK) Ltd. | | Samsung SB | Nov 2007 |
| 105,000 | Teekay Shpg. Canada | | Tsuneishi Zosen | Nov 2007 |
| 110,000 | Yasa Shpg. Industry | | Mitsui SB | Dec 2007 |
| 110,000 | Nanjing Changjiang | | Dalian Shipbld. Ind. | Dec 2007 |
| 105,000 | Kawasaki Kisen | | Namura Zosensho | Dec 2007 |

**Total 51 Vessel(s) of 5,615,070 DWT.**

**2008**

| DWT | Owner | | Builder | Sched. Del. |
|---|---|---|---|---|
| 114,500 | A.P. Moller | c | Sasebo H.I. | 2008 |
| 114,500 | A.P. Moller | c | Sasebo H.I. | 2008 |
| 114,000 | Interorient Nav. Co. | c | New Century S/Y | 2008 |
| 114,000 | Tankerska Plovidba | | Brod. Split | 2008 |
| 114,000 | Interorient Nav. Co. | c | New Century S/Y | 2008 |
| 112,000 | Kuwait Oil Tanker | c | Daewoo SB | 2008 |
| 110,000 | Fratelli D'Amico | | Mitsui SB | 2008 |
| 110,000 | Torm, Dampskibss | c | Dalian Shipbld. Ind. | 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | 2008 |
| 105,000 | Hong Kong Ming Wah | | Sumitomo H.I. | 2008 |
| 105,000 | Hong Kong Ming Wah | | Sumitomo H.I. | 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | 2008 |

# Aframax Tankers (80-120,000 dwt tonnes)

| DWT | Owner | | Builder | Sched. Del. |
|---|---|---|---|---|
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | 2008 |
| 104,900 | DSD Shipping A/S | | Sumitomo H.I. | 2008 |
| 104,000 | Primorsk Shpg. Corp. | | Hyundai H.I. | 2008 |
| 104,000 | Primorsk Shpg. Corp. | | Hyundai H.I. | 2008 |
| 115,000 | Arcadia Shipmngt. | | Samsung SB | Jan 2008 |
| 110,000 | Torm, Dampskibss | c | Dalian Shipbld. Ind. | Jan 2008 |
| 110,000 | Torm, Dampskibss | c | Dalian Shipbld. Ind. | Jan 2008 |
| 110,000 | Fratelli D'Amico | | Mitsui SB | Jan 2008 |
| 105,000 | Teekay Shpg. Canada | | Tsuneishi Zosen | Jan 2008 |
| 115,000 | Novoship (UK) Ltd. | | Samsung SB | Feb 2008 |
| 107,000 | Korea Line | | Namura Zosensho | Feb 2008 |
| 115,000 | Arcadia Shipmngt. | | Samsung SB | Mar 2008 |
| 105,000 | India Steamship Co. | | Hyundai H.I. | Mar 2008 |
| 115,000 | Geden Line | | Samsung SB | Apr 2008 |
| 115,000 | Novoship (UK) Ltd. | | Samsung SB | Apr 2008 |
| 110,000 | Yasa Shpg. Industry | | Mitsui SB | Apr 2008 |
| 104,000 | Primorsk Shpg. Corp. | | Hyundai H.I. | Apr 2008 |
| 115,000 | Cido Shipping | | Sasebo H.I. | May 2008 |
| 115,000 | Cido Shipping | | Sasebo H.I. | Jun 2008 |
| 105,000 | Kyoei Tanker Co. | c | Namura Zosensho | Jun 2008 |
| 115,000 | Geden Line | | Samsung SB | Jul 2008 |
| 110,000 | Meiji Shipping Co. | | Mitsui SB | Jul 2008 |
| 115,000 | Aktif Denizcilik | | STX Shipbuild. | Aug 2008 |
| 112,000 | Overseas Shipholding | | New Century S/Y | Aug 2008 |
| 104,000 | Primorsk Shpg. Corp. | | Hyundai H.I. | Aug 2008 |
| 115,000 | Finaval S.P.A. | | Samsung SB | Sep 2008 |
| 105,000 | Fratelli D'Amato | c | Waigaoqiao S/Y | Sep 2008 |
| 105,000 | Fratelli D'Amato | c | Waigaoqiao S/Y | Sep 2008 |
| 105,000 | Polembros Shpg. | | Hudong Zhonghua | Oct 2008 |
| 115,000 | Aktif Denizcilik | | STX Shipbuild. | Nov 2008 |
| 110,000 | Seaworld Mngt & Trdg | | Tsuneishi Zosen | Nov 2008 |
| 107,000 | Tsakos Energy Nav. | | Sumitomo H.I. | Nov 2008 |
| 107,000 | Tsakos Energy Nav. | | Sumitomo H.I. | Nov 2008 |
| 105,830 | Chambal Fertilisers | | Hyundai H.I. | Nov 2008 |
| 105,000 | Shanghai North Sea | | Waigaoqiao S/Y | Nov 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | Nov 2008 |
| 112,400 | A.M.P.T.C. | c | Hyundai H.I. | Dec 2008 |
| 112,000 | Overseas Shipholding | | New Century S/Y | Dec 2008 |
| 112,000 | Overseas Shipholding | | New Century S/Y | Dec 2008 |
| 105,000 | Shanghai North Sea | | Waigaoqiao S/Y | Dec 2008 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | Dec 2008 |
| 105,000 | Petrovietnam Trans. | | Dung Quat Shipyard | Dec 2008 |

**Total 57 Vessel(s) of 6,219,130 DWT.**

**2009**

| DWT | Owner | | Builder | Sched. Del. |
|---|---|---|---|---|
| 115,000 | Geden Line | | Samsung SB | 2009 |
| 115,000 | Geden Line | | Samsung SB | 2009 |
| 115,000 | American Eagle Tnkrs | | STX Shipbuild. | 2009 |
| 115,000 | Emarat Maritime LLC | | Hanjin H.I. | 2009 |
| 115,000 | American Eagle Tnkrs | | STX Shipbuild. | 2009 |
| 115,000 | Emarat Maritime LLC | | Hanjin H.I. | 2009 |
| 115,000 | Emarat Maritime LLC | | Hanjin H.I. | 2009 |
| 115,000 | American Eagle Tnkrs | | STX Shipbuild. | 2009 |
| 115,000 | Emarat Maritime LLC | | Hanjin H.I. | 2009 |
| 115,000 | Byzantine Maritime. | c | Sungdong S.B. | 2009 |
| 115,000 | Byzantine Maritime. | c | Sungdong S.B. | 2009 |
| 115,000 | Conti Reederei | c | Hyundai H.I. | 2009 |
| 115,000 | Conti Reederei | c | Hyundai H.I. | 2009 |
| 114,500 | A.P. Moller | c | Sasebo H.I. | 2009 |
| 114,000 | Tankerska Plovidba | | Brod. Split | 2009 |
| 114,000 | Interorient Nav. Co. | c | New Century S/Y | 2009 |
| 114,000 | Interorient Nav. Co. | c | New Century S/Y | 2009 |
| 114,000 | Finaval S.P.A. | | Samsung SB | 2009 |
| 114,000 | Finaval S.P.A. | | Samsung SB | 2009 |
| 114,000 | Seaarland Shpg.Mgmnt | c | New Century S/Y | 2009 |
| 114,000 | Seaarland Shpg.Mgmnt | c | New Century S/Y | 2009 |
| 114,000 | Seaarland Shpg.Mgmnt | c | New Century S/Y | 2009 |
| 114,000 | Kyoei Tanker Co. | c | Sasebo H.I. | 2009 |
| 112,000 | Liquimar Tankers | | New Century S/Y | 2009 |
| 112,000 | Novoship (UK) Ltd. | | Hyundai H.I. | 2009 |
| 112,000 | Novoship (UK) Ltd. | | Hyundai H.I. | 2009 |
| 112,000 | Liquimar Tankers | | New Century S/Y | 2009 |
| 112,000 | Novoship (UK) Ltd. | | Hyundai H.I. | 2009 |
| 112,000 | Novoship (UK) Ltd. | | Hyundai H.I. | 2009 |
| 110,000 | China Ocean (COSCO) | | Dalian Shipbld. Ind. | 2009 |
| 110,000 | Fratelli D'Amico | | Mitsui SB | 2009 |
| 110,000 | Unknown Owner | | Mitsui SB | 2009 |
| 110,000 | Unknown Owner | | Mitsui SB | 2009 |
| 110,000 | China Ocean (COSCO) | | Dalian Shipbld. Ind. | 2009 |
| 110,000 | China Ocean (COSCO) | | Dalian Shipbld. Ind. | 2009 |
| 107,000 | Transpetro | | Rio Naval | 2009 |
| 107,000 | Transpetro | | Rio Naval | 2009 |
| 107,000 | Polyar Tankers AS | | Tsuneishi Zosen | 2009 |
| 107,000 | Polyar Tankers AS | | Tsuneishi Zosen | 2009 |
| 107,000 | Transpetro | | Rio Naval | 2009 |
| 105,000 | Cardiff Marine Inc. | c | Waigaoqiao S/Y | 2009 |
| 105,000 | Petrovietnam Trans. | | Dung Quat Shipyard | 2009 |
| 105,000 | Petrovietnam Trans. | | Dung Quat Shipyard | 2009 |
| 105,000 | Dorian (Hellas) S.A. | | Hyundai H.I. | 2009 |
| 105,000 | Dorian (Hellas) S.A. | | Hyundai H.I. | 2009 |
| 105,000 | Cardiff Marine Inc. | | Waigaoqiao S/Y | 2009 |
| 105,000 | Dorian (Hellas) S.A. | | Hyundai H.I. | 2009 |
| 105,000 | Cardiff Marine Inc. | c | Waigaoqiao S/Y | 2009 |
| 105,000 | Cardiff Marine Inc. | | Waigaoqiao S/Y | 2009 |
| 105,000 | Cardiff Marine Inc. | c | Waigaoqiao S/Y | 2009 |
| 105,000 | Cardiff Marine Inc. | c | Waigaoqiao S/Y | 2009 |
| 115,000 | Chandris (Hellas) | c | Samsung SB | Jan 2009 |
| 115,000 | Finaval S.P.A. | | Samsung SB | Jan 2009 |
| 115,000 | Aktif Denizcilik | | STX Shipbuild. | Jan 2009 |
| 110,000 | Seaworld Mngt & Trdg | | Tsuneishi Zosen | Jan 2009 |
| 107,000 | Korea Line | | Namura Zosensho | Jan 2009 |
| 105,830 | Chambal Fertilisers | | Hyundai H.I. | Feb 2009 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | Feb 2009 |
| 115,000 | Chandris (Hellas) | c | Samsung SB | Mar 2009 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | Mar 2009 |
| 105,000 | Polembros Shpg. | | Hudong Zhonghua | Mar 2009 |
| 105,000 | Phoenix Energy Nav. | | Hyundai H.I. | Mar 2009 |
| 112,000 | Overseas Shipholding | | New Century S/Y | Apr 2009 |
| 115,000 | Aktif Denizcilik | | STX Shipbuild. | May 2009 |
| 112,400 | A.M.P.T.C. | c | Hyundai H.I. | May 2009 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | May 2009 |
| 105,000 | India Steamship Co. | | Hyundai H.I. | Jun 2009 |
| 105,000 | Phoenix Energy Nav. | | Hyundai H.I. | Jun 2009 |
| 105,000 | Polembros Shpg. | | Hudong Zhonghua | Jun 2009 |
| 115,000 | Golden Energy Mngt. | | Sungdong S.B. | Jul 2009 |
| 115,000 | Golden Energy Mngt. | | Sungdong S.B. | Jul 2009 |
| 115,000 | Golden Energy Mngt. | | Sungdong S.B. | Jul 2009 |
| 115,000 | Golden Energy Mngt. | | Sungdong S.B. | Jul 2009 |
| 105,000 | Ocean Tankers Pte. | | Waigaoqiao S/Y | Jul 2009 |
| 107,000 | Transpetrol Services | | Tsuneishi Zosen | Aug 2009 |
| 105,000 | Tsakos Energy Nav. | | Sumitomo H.I. | Aug 2009 |
| 115,000 | Kristen Navigation | | Hyundai H.I. | Sep 2009 |
| 105,000 | Polembros Shpg. | | Hudong Zhonghua | Sep 2009 |

## Aframax Tankers (80-120,000 dwt tonnes)

| DWT | Owner | | Builder | Sched. Del. | DWT | Owner | Builder | Sched. Del. |
|---|---|---|---|---|---|---|---|---|
| 105,000 | Emirates Trading | c | Hyundai H.I. | Sep 2009 | | | | |
| 105,000 | SK Shipping Co. Ltd. | c | Hyundai H.I. | Oct 2009 | | | | |
| 105,000 | SK Shipping Co. Ltd. | c | Hyundai H.I. | Nov 2009 | | | | |
| 105,000 | Tsakos Energy Nav. | | Sumitomo H.I. | Nov 2009 | | | | |
| 105,000 | Emirates Trading | c | Hyundai H.I. | Nov 2009 | | | | |
| 115,000 | Kristen Navigation | | Hyundai H.I. | Dec 2009 | | | | |
| **Total 84 Vessel(s) of 9,256,730 DWT.** | | | | | | | | |
| | | | **2010** | | | | | |
| 115,000 | Geden Line | | Samsung SB | 2010 | | | | |
| 115,000 | Geden Line | | Samsung SB | 2010 | | | | |
| 107,000 | Transpetro | | Rio Naval | 2010 | | | | |
| 107,000 | Transpetro | | Rio Naval | 2010 | | | | |
| 107,000 | Transpetrol Services | | Tsuneishi Zosen | Jan 2010 | | | | |
| **Total 5 Vessel(s) of 551,000 DWT.** | | | | | | | | |

Source: Clarkson Research Services, (2006), *Shiptype Orderbook Monitor*, **Volume 13**, No.12.

# APPENDIX 5 YARD COMPARISON

For the conversion project under consideration the three major items are staging, blasting and paint application in the cargo holds. The actual paint material cost will be the same regardless of geographic location. For the purpose of comparison unit costs for the above mentioned items are examined, having as pilot basis shipyards in different geographical locations, namely; Europe (Atlantic), Europe (Black Sea), Singapore and China. The following table was drawn (2006 Data);

| Shipyard in Region | Europe (Atlantic) | Europe (Black Sea) | Singapore | China |
|---|---|---|---|---|
| Staging $/m3 | 10 | 5 | 6 | 3 |
| Grit Blasting $/m2 | 30 | 15 | 25 | 11 |
| Paint Application $/m2 | 0.5 | 0.5 | 0.5 | 0.5 |

Table 7-4

The price difference between China and other places of the world is evident. Further to the price base however, other factors will have to be considered such as the time quotation, and quality of the final product. For a labour intensive project such as the one considered, China has the competitive edge in terms of completion time, while it is also believed that with the correct supervision a high standard can be achieved. In any case, significant cost savings both in terms of work cost and downtime are usually the deciding factors.

Source: Astron Maritime, Phoenix Energy Navigation, (2005, 2006), *Prices based on quotations received from Shipyards for the Dry-docking of MT Compass I, MT Sentosa Spirit. MT Seraya Spirit, MT Seletar Spirit, MT Semacau Spirit, MV Arisbe, MV Astron Spirit.* Private and Confidential.

# APPENDIX 6 MARPOL 73/78

## 1.1 The International Convention for the Prevention of Pollution from Ships

The International Convention for the Prevention of Pollution from Ships (MARPOL) is a combination of two treaties adopted in 1973 and 1978 respectively, concerned with the prevention of pollution of the marine environment by ships. This convention covers pollution issues both from operational and accidental causes and has been developed and updated by amendments throughout the years.

The regulations included in the convention, aim at preventing and minimizing pollution from ships, both accidental and from routine operations, and currently include six Annexes.

| | |
|---|---|
| Annex I | Regulations for the Prevention of Pollution by Oil |
| Annex II | Regulations for the Control of Pollution by Noxious Liquid substances in Bulk |
| Annex III | Prevention of Pollution by Harmful substances Carried by sea in Packaged Form |
| Annex IV | Prevention of Pollution by Sewage from Ships |
| Annex V | Prevention of Pollution by Garbage from Ships |
| Annex VI | Prevention of Air Pollution from Ships |

State Parties must accept Annexes I and II while the other Annexes are voluntary.

As this research project is concerned with converting single skin to double skin vessels Annex I of the convention is of prime importance.

## 1.2 The Creation of MARPOL 73/78 for the Prevention of Pollution by Oil (Annex I)

Ever since oil has played a major role in the development and formation of the modern world it has been identified as a major pollutant of the marine environment. The risk that bulk transportation of oil incurs to the marine environment increased as technology advanced and the carrying capabilities of vessels became greater. It soon became clear, through a series of accidents, that a single case of pollution was enough to change the face and environmental soundness of an entire bio-system with irreversible effects.

***OILPOL 1954***

Various countries started introducing national regulations to control discharges of oil within their territorial water as early as the first half of the 20$^{th}$ century. In 1954 a conference was organized by the United Kingdom which resulted in the adoption of the International Convention for the Prevention of Pollution of the sea by Oil (OILPOL), 1954. This convention which was amended in 1962, 1969 and 1971 primarily addressed pollution resulting from routine tanker operations and from the discharge of oily wastes from machinery spaces. These at the time were regarded as the main causes of pollution by ships.

The 1954 OILPOL convention entered into force on 26 July 1958 establishing "prohibited zones" and promoting oil reception facilities ashore. More specific:

- The discharge of oil or of mixtures containing more that 100 parts of oil per million was forbidden at a range extending at least 50 miles from the nearest land
- Contracting Parties were required to take all appropriate steps to promote the provision of facilities for the reception of oily water and residues

In 1962 the International Maritime Organization (IMO) adopted amendments to the convention extending the "prohibited zones" and making it applicable o vessels of lower tonnage.
Furthers amendments in 1969 contained regulations further restricting operational discharge of oil from oil tankers and from machinery spaces of all ships.

The 1954 OILPOL convention was a first step and went some way in dealing with oil pollution. It soon became clear though that further action was required to keep up with the pace of an ever growing oil industry.

***M/T Torrey Canyon grounding***

History has repeatedly shown that a no matter how many signs exist and voices of concerns are raised, a major accident must happen before preventative measures are taken. In 1967 the reality of a major oil pollution accident struck in a hard way. While entering the English Channel the tanker ***M/T Torrey Canyon*** ran aground on the Scilly Isles and lost her entire cargo into the sea. The side effects were tremendous resulting into the greatest oil pollution ever recorded up to that time. This accident not only raised questions about existing measures preventing oil pollution from ships but also exposed deficiencies in the existing system for providing compensation following accidents at sea. The trigger for a major reform of the marine industry was pulled.

***1973 Conference***

With the questions about restraints on the contamination of the sea, land and air hitting news headlines the IMO decided in 1969 to convene an international conference in 1973 to prepare a suitable international agreement addressing the above issues. As this was not deemed enough in the meantime, in 1971, additional amendments to OILPOL 1954 were made relating to the protection of the Great Barrier Reef of Australia and limiting the size of tanks in oil tankers.

The International Convention for the Prevention of Pollution from Ships was finally adopted at the international conference of 1973. In this conference it was recognized that accidents like the one of the ***M/T Torrey Canyon*** were spectacular with tremendous side-effects but the operational pollution was still considered to be the biggest threat. As a result the 1973 convention in Annex I, incorporated, much of the existing frame of OILPOL 1954 and its amendments. In order for this convention to enter into force it required ratification by 15 states with a combined merchant fleet of not les than 50% of the world shipping by gross tonnage. The unwillingness of most of the states to sign and become Party to the convention despite its importance, made it look as though it might never enter into force.

***1978 Conference***

A series of tanker accidents during 1976-1977 raised voices again and pushed for the implementation of immediate measures. A conference was held from the IMO on tanker safety and pollution prevention in February 1978 adopting measures affecting tanker design and operation. The measures were incorporated into both the protocol of 1978 relating to the 1974 Convention on the Safety of Life at Sea (1978 SOLAS Protocol) and the protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from ships (1978 MARPOL Protocol) – adopted on 17 February 1978.

The 1978 MARPOL Protocol absorbed the parent convention of 1973 creating the International Convention for the Prevention of Marine Pollution from ships 1973 as modified by the protocol of 1978 relating thereto (MARPOL 73/78). Annex I of the convention for the prevention of pollution by oil finally entered into force on 2 October 1983.

The regulating frame concerned with tanker oil pollution including Annex I of MARPOL 73/78, has evolved dynamically throughout the years with various amendments and additions, adapting to the lessons learnt over every period and forming the face of today's oil industry. The great importance of MARPOL Annex I, towards the protection of the environment against marine pollution is unquestionable.

### 1.3 Regulation for phase out of single hull tankers

Subsequent to the ***M/T Exxon Valdez*** oil pollution accident, the US introduced the oil pollution act of 1990 (OPA 90) which included provisions for the double hulling of oil tankers. All new tankers trading within the U.S waters were required to be of double hull construction and a phase out scheme was established for existing single hull tankers. New oil tankers under OPA 90 included tankers built after 1990, but for tankers already on order it also included tankers delivered up to January 1, 1994. Starting from 1995 older single hull tankers were phased out based upon the year of build, gross tonnage and whether they had been fitted either with double bottoms or double sides with a final phase out date of 2015. The final phase out dates for the newer vessels as covered by OPA 90 are presented in the table below.

| Tanker Vessel Type | Date of Delivery | Double Hull Required |
|---|---|---|
| 5,000 to less than 15,000 Gross Tons – Single Hull | December 31, 1984 or later | January 1, 2010 |
| 5,000 to less than 15,000 Gross Tons – Single Hull W/Double Side or Double Bottom | December 31, 1984 or later | January 1, 2015 |
| 15,000 to less than 30,000 Gross Tons – Single Hull | December 31, 1984 or later | January 1 ,2010 |
| 15,000 to less than 30,000 Gross Tons – Single Hull W/Double Side or Double Bottom | December 31, 1984 or later | January 1 2015 |
| 30,000 Gross Tons or More – Single Hull | December 31, 1986 or later | January 1, 2010 |
| 30,000 Gross Tons or More – Single Hull W/Double Side or Double Bottom | December 31, 1986 or later | January 1. 2015 |

OPA 90 triggered changes to the existing framework of the MARPOL 73/78 convention. International requirements for double hulling of oil tankers were introduced by the IMO. An amendment to Annex I of MARPOL in 1992 made it mandatory for the double hulling of oil tankers, with new build vessels covered by regulation 13F and regulation 13G applying to existing crude oil tankers.

The scheme adopted by the IMO was not identical to the OPA 90. For example the U.S. does not agree that MARPOL Annex I, Regulation13G's operational measures to reduce the outflow of oil that results from a grounding or collision are equivalent to a double hull.

Under the revised MARPOL convention new tankers included those built after 1993, but for those already on order it included those delivered up to 1996. Only large tankers, over 20,000 dwt tonnes carrying crude oil, fuel oil, heavy diesel oil or lubricating oil as cargo and product tankers over 30,000 dwt, were subject to MARPOL amendments. The phase out commencing as from 6 July 1995 originally exempted double hulling of vessels having been built under regulation 13E until they reached the age of 30.

On December 12, 1999 the oil tanker ***M/T Erika,*** a 25 year old single-hull vessel broke into two 40 miles off the coast of Brittany spilling 15,000 tonnes of heavy fuel oil. Between Christmas and the end of March more than 10,000 tonnes of oil came ashore along 400-500 km of the French Biscay coastline with the most devastating environmental effect Europe had ever experienced.

Investigations led by the French government and the Maltese maritime Authority concluded that the failure of the vessel was a combination of a number of variables. The age of the vessel, corrosion, insufficient maintenance and inadequate surveys were all considered to be contributing factors affecting the structural failure of the vessel.

Following the sinking of ***M/T Erika***, the EU commission proposed a phase out scheme for single hull tankers similar to the US OPA90. Discussions with the IMO led to a new, accelerated phase-out schedule for single-hull tankers – the revision of regulation 13G of MARPOL 73/78. Subsequently the EU adopted Regulation 417/2002.

In December 2003, following another high profile incident "the sinking of the ***M/T Prestige*** off the coast of Spain", the EU Commission proposed to accelerate the phase out scheme approved in 2001 to align it with the relevant phase out dates of the OPA 90. Regulation 417/2002 was thus amended by means of Regulation 1726/2003 and thereafter the matter was referred to the IMO. With the adoption of Regulation 1726/2003, the EU is following a policy for the phase out of single hull tankers which is in many aspect's stricter than OPA90.

A proposal was submitted to the IMO to have these stricter safety standards apply to the entire world fleet. Further amendments were made to Annex I of MARPOL in alignment with the EU regulations, accelerating the phase out scheme for single hull tankers of 5,000 tons deadweight and above, and imposing new requirements for the carriage of heavy grade oil as cargo (Revised Reg. 13G and New Reg. 13H).

Under revised regulation 13G three categories of tankers are identified according to their certified arrangements and the type of oil carried as cargo.

- “Category 1 oil tanker”. Oil tankers of 20,000 tons deadweight and above carrying crude oil, fuel oil, heavy diesel oil or lubricating oil as cargo, and of 30,000 tons deadweight and above carrying other oils, which do not comply with the requirements for oil tankers as defined in Reg. 1(26) of Annex I.

- "Category 2 oil tanker". Oil tankers of 20,000 tons deadweight and above carrying crude oil, fuel oil, heavy diesel oil or lubricating oil as cargo, and of 30,000 tons deadweight and above carrying other oils, which do comply with the requirements for new oil tankers as defined in Reg. 1(26) of Annex I.

- "Category 3 oil tanker". Oil tankers of 5,000 tons deadweight and above but less than the tonnage specified for Category 1 and 2 tankers.

The above single hull tanker categories are subjected to the phase out scheme presented in the following table.

| SINGLE SKIN TANKER PHASE OUT SCHEME | |
|---|---|
| Oil Tanker Category | Phase out Date |
| Category 1 | 5 April 2005 for ships delivered on 5 April 1982 or Earlier<br>2005 for Ships delivered after 5 April 1982 |
| Category 2 | 5 April 2005 for ships delivered on 5 April 1977 or earlier<br>2005 for ships delivered after 5 April 1977 but before 1 January 1978<br>2006 for ships delivered in 1978 and 1979<br>2007 for ships delivered in 1980 and 1981<br>2008 for ships delivered in 1982<br>2009 for ships delivered in 1983<br>2010 for ships delivered in 1984 or later |
| Category 3 | As per Category 2 |

For category 2 and 3 tankers a successful completion of the Condition Assessment Scheme (CAS) is required. The CAS was adopted in 2001 as a complement to the requirements of the Enhanced Survey Programme that comes into force by 15 years of age or by the first intermediate or renewal survey after 5 April 2005, which ever occurs later. The CAS survey main requirements include enhanced and transparent verification of the structural condition of single hull oil tankers and verification that the documentary and survey procedures have been properly carried out and completed.

Further to revised regulation13G and the CAS survey a new MARPOL regulation 13H on the prevention of oil pollution from oil tankers when carrying heavy grade oil has been adopted. Since the 5th of April 2005 regulation 13H bans the carriage of HGO in single-hull tankers of 5,000 tons dwt and above and in single-hull oil tankers of 600 dwt and above but less than 5,000 tons dwt, not later than the anniversary of their delivery date in 2008.

Under the new regulation, HGO means any of the following:
a) crude oils having a density at 15ºC higher than 900 kg/m3;
b) fuel oils having either a density at 15ºC higher than 900 kg/ m3 or a kinematic viscosity at 50ºC higher than 180 mm2/s;
c) bitumen, tar and their emulsions.

Although the new phase-out timetable sets 2010 as the principal cut-off date for all single-hull tankers, the flag state administration may allow for some newer single hull ships under their registry, that satisfy certain technical requirements, to continue trading until the 25th anniversary of their delivery. These include vessels fitted with double bottom, or double sides, or double hull (of dimensions smaller than those dictated by Reg. 13F) subject to that they provide protection to the entire cargo length and that the spaces are not used for the carriage of oil.

In the same manner however provision is made for a port state to deny entry to such ships into port and terminals. A number of countries have already clarified their policies, as Flag States and as Port States, regarding implementation of various provisions in Regulation 13G as amended and Regulation 13H.

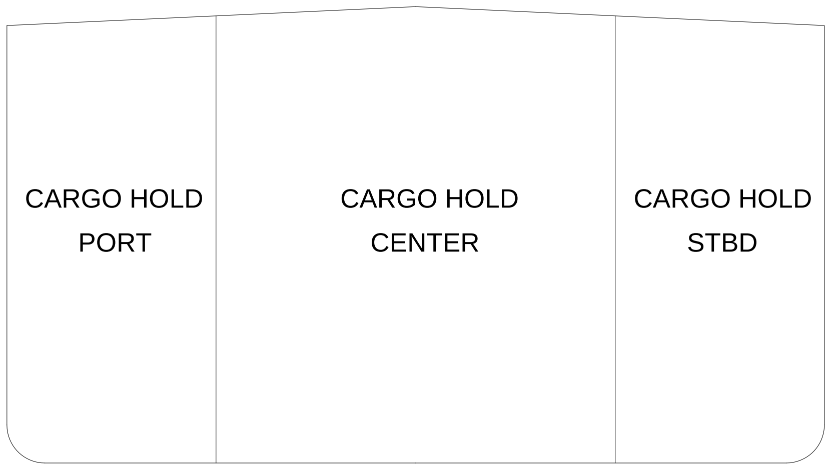
In general terms the revised Annex I is in line with the EU regulation. However the 25 EU Member states have already announced that they will not make use of the above exemptions.

Sources: 1.International Maritime Organization, (2006), *Oil tankers regulation 20/21 implementation,* http://www.imo.org 2.International Maritime Organization, (2002), *MARPOL 73/78 Consolidated Edition,* IMO, London.

# APPENDIX 7 TANKER VESSEL EVOLUTION

In order to understand the form of today's tanker vessel's it is necessary to take a step back and examine the phases they went though in conjunction with the regulatory frame in force during each period.

Early day tankers were of single skin construction. A typical section of one is demonstrated in the sketch below.




Typical Section of Pre-MARPOL 73/78 Tanker
Fig.1

It was normal practice of the early days to use the same tanks for cargo and ballast water carrying purposes. After cargo oil discharge, in order to satisfy the propeller immersion draft requirements and proceed to the next load port, a number of tanks were cleaned using seawater jets and were then used as ballast tanks. The mixture of oil and water resulting from the cleaning operations was collected at the bottom of the tanks and was then pumped overboard. Ballast water used during transit was also contaminated, and at the end of the voyage, was in turn pumped overboard. Oil pollution conventions that were gradually established started promoting measures to counter the pollution of such operations. Thus, as mentioned before, the 1954, 1962 and 1969 conventions promoted and extended "prohibited zones" and took various other measures restricting pollution from marine operations, while the 1971 conference limited the size of tanks in oil tankers. Amid great concern about the waste of oil and pollution caused by the current practice of tank cleaning, a new method, know as the Load on Top method was developed. This method, as the previous one, used high pressure hot water cleaning machines but instead of pumping the wastes directly overboard, they were directed to a special slop tank. During the ballast voyage, the oil and water mixture existing in the slop tanks naturally separate. Oil, being lighter than water starts flowing to the top of the slop tank leaving water at the bottom. The water then can be pumped into the sea leaving only crude oil in the tank. When arriving at the loading terminal crude oil can now be loaded on top of the oil still existing in the slop tank. This method has repeatedly been described as a revolutionary method. The benefits were readily visible in the commercial side of the business with an immeasurable positive impact on the environment. It has since been estimated that oil being dumped into the sea as a result of tank cleaning could have reached in excess of 8 million tons a year. The Load on Top method was recognized as an effective method towards the prevention of pollution by oil by the 1973 MARPOL convention.

In general terms the 1973 convention maintained the criteria prescribed in the 1969 amendments to the 1954 Oil pollution Convention. These were mainly concerned with the quantity of oil discharged, the rate of discharge and the distance from land this could take place. More precisely:

- In any ballast voyage the tanker should not discharge whilst under way quantity of oil exceeding 1/15,000 of the total carrying capacity of the vessel.
- The rate of this discharge should not exceed 60 litres per mile travelled
- And no discharge of any oil from cargo spaces of a tanker is allowed within 50 miles of the nearest land.
- An oil record book is required in which the movement of cargo oil and its residues is recorded on a tank to tank basis from loading to discharging.

In addition to the above measures of previous conventions and the recognition of the Load on top method the 1973 Convention introduced a number of “new” regulations.

A completely new concept up to that day, the concept of special areas, was brought into force. According to this concept some areas around the globe such as, the Mediterranean Sea, the Black Sea, the Baltic Sea, and the Gulfs area were identified as special areas. These places are considered to be so vulnerable to pollution by oil that oil discharges within them are completely prohibited, with minor and well defined exemptions. Thus, oil carrying ships are required to be capable of retaining all their oily wastes on board through the load on top method or for discharge to a shore facility. The above meant that a variety of appropriate equipment such as oil discharge monitoring and control systems, oily water separating equipment and a filtering systems, as well as slop tanks and sludge tanks with the relevant piping and pumping arrangements had to be fitted to the vessels.

In relation to fresh tonnage expected to enter the market the 1973 convention required tankers of 70,000 dwt and above to be fitted with segregated ballast tanks. These tanks should be large enough to provide the required draught during ballast operations eliminating the need of carrying ballast water in cargo oil tanks. Moreover certain subdivision and damage stability requirements that ensure the vessels survival ability after damage by collision or stranding were introduced. Furthermore the amount of oil that each tanker could discharge during a ballast voyage was further reduced for new tankers to 1/30,000 of the amount of cargo carried.

As mentioned the resolutions of the 1973 Convention did not come into force until after the 1978 Convention as most states did not appear willing to become Party to it. Nonetheless it was proved that regulating the amount and rate of oil discharge did not completely eliminate pollution resulting from tank cleaning operations, which was still significant.

In the late 70s another innovative method was introduced, the method of crude oil washing. By using this method the cargo itself is used for cleaning purposes and the vessels is left with virtually no slops. Sediments left over on the tank walls while discharging, dissolve when oil from the remaining cargo is sprayed on them. Thus sediments are turned back to usable oil that can be pumped off with the rest of the cargo. As with the load on top method the crude oil washing method ensures even less pollution as a side effect of tank cleaning. Moreover the owner is now able to discharge far more cargo than before increasing his profit.

This breakthrough method was adopted by the 1978 Convention for all new tankers. Changes were also made to Annex I of the 1973 parent convention. Segregated ballast tanks were now required on all new tankers of 20,000 dwt and above. These ballast tanks had to be located in such a position as to protect the cargo in the event of collision or grounding (Regulation 13E). Attention should be paid as “protective location of segregated ballast tanks” does not automatically imply that vessels from that point on should be built having protective ballast tanks located either on the vessels sides or as a double bottom. Vessels of the single-single construction, with dedicated ballast tanks, also comply with Regulation 13E depending on their design. Consequently a number of different designs came to the surface during that period. Generally speaking vessels built from that point on can be split in the following categories

1. Single- single skin construction vessels as before with segregated ballast tanks placed in different positions along the length of the vessel.

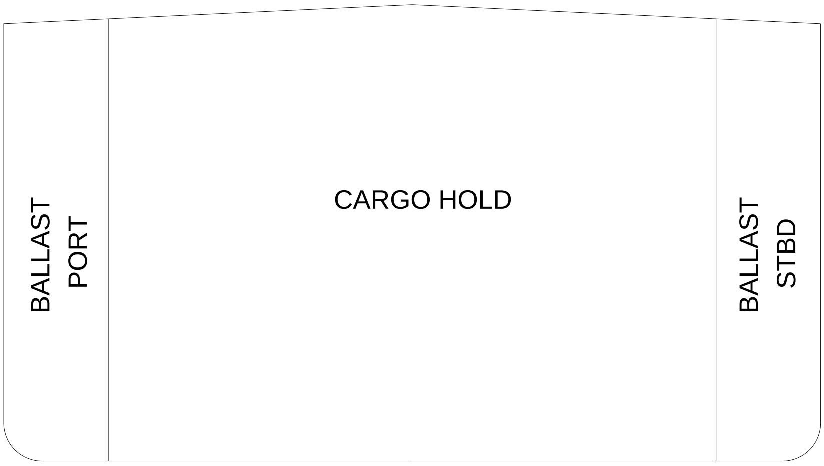
2. Double side with ballast tanks placed along the side of the vessel.

3. Double bottom with ballast tanks placed along the bottom of the vessel.

4. Fully double hulls.

5. Various other designs combinations of the above.

A “typical” section of a tanker with ballast tanks on its port and starboard side, built after the Implementation of the convention is illustrated bellow.




"Typical" Section of Post- MARPOL 73/78 Tanker
Fig.2

For existing tankers the method of crude oil washing described previously was accepted as an alternative to segregated water ballast tanks. A third alternative was also offered for a period of two to four years after entry of the convention into force. Vessels had to dedicate a number of cargo tanks that would satisfy the draught requirements and would be used solely for the carriage of ballast water, known as dedicated clean ballast tanks (CBT). Thus by modifying a number of piping and pumping arrangements the vessels could continue to trade for a short period. As a result most existing tankers converted their Port and Starboard Cargo tank located closest amidships into dedicated clean water ballast tanks. This though was not a permanent measure and when the period of grace had expired other systems had to be used.

Other measures introduced by the 1978 convention were alternations to the existing drainage and discharge arrangement of the vessel and regulations for improved stripping systems. The exemption from the regulations of certain tankers designs that can operate without the use of ballast water, or that operate in specific trades between ports with adequate reception facilities was recognized. Finally, in order for the regulation to be obeyed, the 1978 protocol introduced stricter enforcement regulations for the survey and certification of ships.

On March 24, 1989 the ***M/T Exxon Valdez*** struck well-charted Bligh Reef in Alaska's Prince William Sound, ripping open eight of its 11 cargo tanks. According to Exxon 11 million gallons of oil were spilled into an extremely sensitive marine environment. The huge slick eventually spread over 10,000 square miles of Alaska's coastal seas and as far as 600 miles from the reef resulting in the greatest environmental damage ever of the United States coastline.

In the wake of the spill of the ***M/T Exxon Valdez***, the United State Congress passed the Oil Pollution Act of 1990 (OPA 90) which made mandatory the double hulling of oil tankers. OPA 90 triggered changes to the existing framework of the MARPOL 73/78 convention. An amendment to Annex I of MARPOL in 1992 made it mandatory for the double hulling of oil tankers.

A typical midship's section of a modern day tanker as it evolved complying with the latest regulations is illustrated bellow.

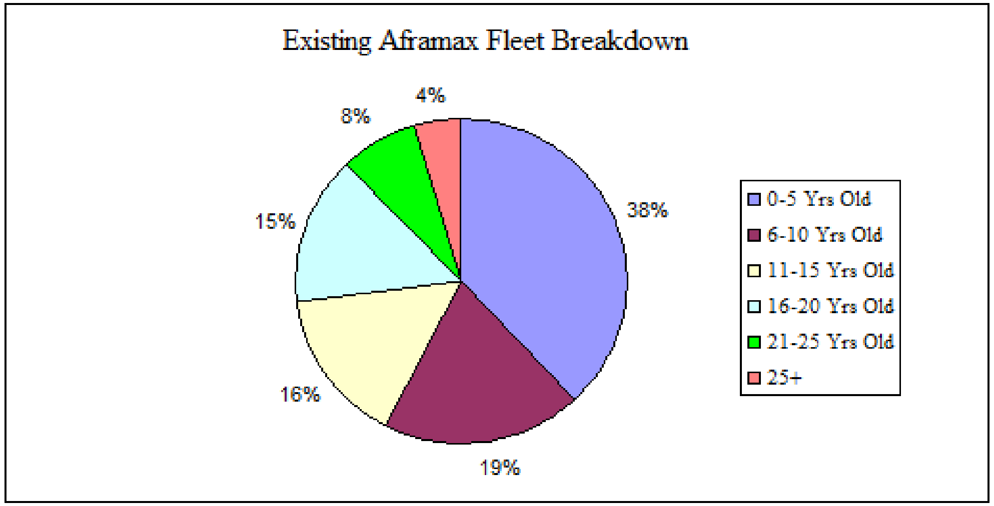

Typical Section of Present-Day Tanker

Fig.3

Sources: 1. International Maritime Organization, (2006), *Oil tankers regulation 20/21 implementation*, http://www.imo.org 2. General Energy and Transport, (2004), *Oil Tanker Phase Out and the Ship Scrapping Industry*, European Commission, Brussels.

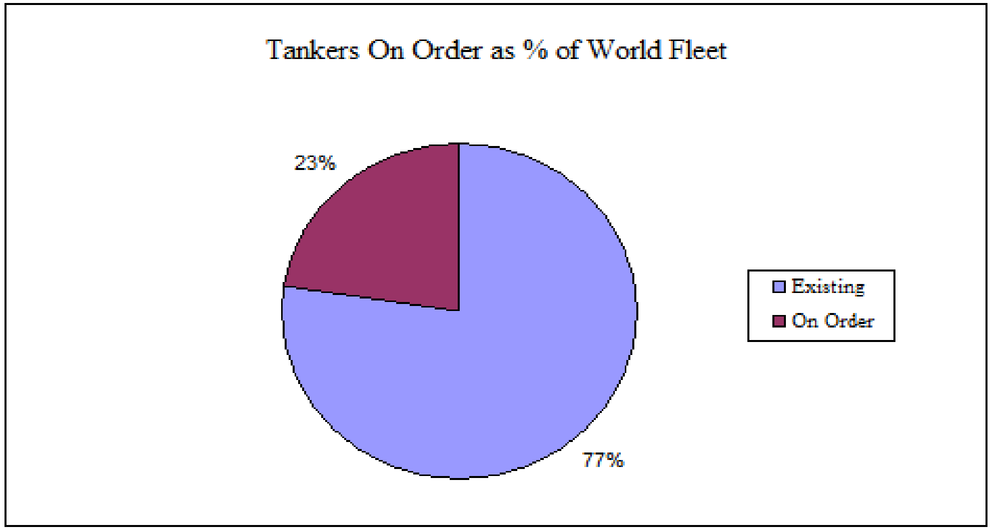
# APPENDIX 8 AFRAMAX TANKER FLEET INFORMATION

| Aframax Age Profile | | |
|---|---|---|
| **Age** | **Kdwt** | **Vessels** |
| 0-5 Yrs Old | 28,704 | 267 |
| 6-10 Yrs Old | 14,088 | 136 |
| 11-15 Yrs Old | 10,631 | 109 |
| 16-20 Yrs Old | 9,970 | 105 |
| 21-25 Yrs Old | 5,067 | 55 |
| 25+ | 2,826 | 31 |
| On Order | 22,986 | 209 |
| **Total** | **94,272** | **912** |




| Aframax Delivery Schedule | | |
|---|---|---|
| **Year** | **Kdwt** | **Vessels** |
| 2006 | 1,756 | 14 |
| 2007 | 5,615 | 51 |
| 2008 | 6,229 | 57 |
| 2009 | 8,835 | 80 |
| 2010 | 551 | 9 |
| **Total** | **22,986** | **211** |

| Aframax Scrappings | | |
|---|---|---|
| **Year** | **Kdwt** | **Vessels** |
| 1999 | 2,715 | 30 |
| 2000 | 1,833 | 19 |
| 2001 | 1,546 | 17 |
| 2002 | 1,764 | 20 |
| 2003 | 3,701 | 41 |
| 2004 | 2,518 | 27 |
| 2005 | 1,722 | 19 |
| 2006 (OCT) | 827 | 9 |
| **Total** | **16,626** | **182** |




Source: Clarkson Database as of October 1 2006.

# APPENDIX 9 OIL CARGOES TRANSPORTED IN THE PACIFIC BASIN

| **CARGO TYPE** | **API Deg.** | **SG $t/m^3$** | **CARGO TYPE** | **API Deg.** | **SG $t/m^3$** |
|---|---|---|---|---|---|
| Al Shaheen Crude nhc | 29 | 0.882 | Jet Oil no heat | 48.4 | 0.787 |
| Arabian Medium nhc | 28.9 | 0.882 | Kerapu Crude heated | 46.5 | 0.795 |
| Arabian Medium nhc | 28.9 | 0.882 | Kidurong Crude nhc | 36.1 | 0.844 |
| Arun Condensate nhc | 57.5 | 0.749 | Legendre Crude nhc | 43 | 0.811 |
| Attaka Crude nhc | 43.5 | 0.809 | Light Cycle Oil heated | 23.5 | 0.913 |
| Bach Ho Crude heated | 40.2 | 0.824 | Liuhua Crude heated | 21.5 | 0.925 |
| Bayu Undan nhc | 63.2 | 0.727 | Low Sulphur Decant heat | 5 | 1.037 |
| Bekapai nhc | 44.5 | 0.804 | LSWR heated | 25.1 | 0.904 |
| Benchamas Crude heat | 42.4 | 0.814 | Minas Crude heat | 35.3 | 0.849 |
| Bintulu Condensate nhc | 59.8 | 0.740 | Mudi Crude nhc | 38 | 0.835 |
| Bintulu Crude nhc | 36.5 | 0.842 | Murban nhc | 39.9 | 0.826 |
| Bunga Kekwa Crude heated | 36.9 | 0.840 | Nanhai Crude heated | 38.8 | 0.831 |
| Canadian Crude nhc | 36 | 0.845 | North West Shelf Cond. nhc | 60.3 | 0.738 |
| Carbon Black Feedstock heated | -0.9 | 1.083 | Oman Crude nhc | 32.9 | 0.861 |
| Champion Crude nhc | 28.8 | 0.883 | Qin Huang Dao Crude heated | 16.6 | 0.955 |
| Cinta Crude heat | 31 | 0.871 | Rang Dong Crude heated | 39.9 | 0.826 |
| Comingled Condensate nhc | 57.3 | 0.749 | Ruby Crude heated | 35.7 | 0.846 |
| Cooper Basin Crude nhc | 48.9 | 0.785 | Senipah Condensate nhc | 52.4 | 0.769 |
| Cossack Crude nhc | 47.7 | 0.790 | Sepinggan Crude nhc | 31 | 0.871 |
| Decant Oil heated | 13.6 | 0.975 | Seria Light Export Blend nhc | 36.4 | 0.843 |
| Duri Crude heated | 20.9 | 0.928 | Stag Crude nhc | 18.4 | 0.944 |
| Elang Condensate nhc | 56.9 | 0.751 | Straight Run Fuel Oil heated | 16 | 0.959 |
| Fuel Oil heated | 15 | 0.966 | Su Tu Den Crude heated | 36.2 | 0.844 |
| Gippsland Blend nhc | 48.7 | 0.785 | Sumatran Light Crude Oil nhc | 34.6 | 0.852 |
| Griffin Crude nhc | 54 | 0.763 | Tapis Blend Crude nhc | 45.8 | 0.798 |
| Handil Mix Crude low heat | 43 | 0.811 | Varanus Crude nhc | 47.3 | 0.791 |
| High Sulphur Gas Oil nhc | 18 | 0.946 | Wandoo Crude nhc | 19.4 | 0.938 |
| HSFO 180 Cst heated | 12.4 | 0.983 | West Seno Crude nhc | 41 | 0.820 |
| HSFO 280 Cst heated | 11.9 | 0.987 | Widuri Crude heated | 32.8 | 0.861 |
| HSFO 380 Cst heated | 11.5 | 0.990 | Woollybutt Crude nhc | 48.6 | 0.786 |

Source: Teekay Marine Services, (2006), *Cargoes Transported by the TK fleet in the Pacific Basin*, Personal Contact.

# APPENDIX 10 PORT STATE POLICY ANALYSIS

| CARGO TYPE | API Deg. | SG $t/m^3$ | Australia | Honk Kong | India | Japan | China | Singapore | South Korea |
|---|---|---|---|---|---|---|---|---|---|
| Al Shaheen Crude nhc | 29 | 0.882 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Arabian Medium nhc | 28.9 | 0.882 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Arabian Medium nhc | 28.9 | 0.882 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Arun Condensate nhc | 57.5 | 0.749 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Attaka Crude nhc | 43.5 | 0.809 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Bach Ho Crude heated | 40.2 | 0.824 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Bayu Undan nhc | 63.2 | 0.727 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Bekapai nhc | 44.5 | 0.804 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Benchamas Crude heat | 42.4 | 0.814 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Bintulu Condensate nhc | 59.8 | 0.740 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Bintulu Crude nhc | 36.5 | 0.842 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Bunga Kekwa Crude heated | 36.9 | 0.840 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Canadian Crude nhc | 36 | 0.845 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Carbon Black Feedstock heated | -0.9 | 1.083 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Champion Crude nhc | 28.8 | 0.883 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Cinta Crude heat | 31 | 0.871 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Comingled Condensate nhc | 57.3 | 0.749 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Cooper Basin Crude nhc | 48.9 | 0.785 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Cossack Crude nhc | 47.7 | 0.790 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Decant Oil heated | 13.6 | 0.975 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Duri Crude heated | 20.9 | 0.928 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Elang Condensate nhc | 56.9 | 0.751 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Fuel Oil heated | 15 | 0.966 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Gippsland Blend nhc | 48.7 | 0.785 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Griffin Crude nhc | 54 | 0.763 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Handil Mix Crude low heat | 43 | 0.811 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| High Sulphur Gas Oil nhc | 18 | 0.946 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| HSFO 180 Cst heated | 12.4 | 0.983 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| HSFO 280 Cst heated | 11.9 | 0.987 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| HSFO 380 Cst heated | 11.5 | 0.990 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Jet Oil no heat | 48.4 | 0.787 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Kerapu Crude heated | 46.5 | 0.795 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Kidurong Crude nhc | 36.1 | 0.844 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Legendre Crude nhc | 43 | 0.811 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Light Cycle Oil heated | 23.5 | 0.913 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Liuhua Crude heated | 21.5 | 0.925 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Low Sulphur Decant heat | 5 | 1.037 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| LSWR heated | 25.1 | 0.904 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Minas Crude heat | 35.3 | 0.849 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Mudi Crude nhc | 38 | 0.835 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Murban nhc | 39.9 | 0.826 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Nanhai Crude heated | 38.8 | 0.831 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| North West Shelf Cond. Nhc | 60.3 | 0.738 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Oman Crude nhc | 32.9 | 0.861 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Qin Huang Dao Crude heated | 16.6 | 0.955 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Rang Dong Crude heated | 39.9 | 0.826 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Ruby Crude heated | 35.7 | 0.846 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Senipah Condensate nhc | 52.4 | 0.769 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Sepinggan Crude nhc | 31 | 0.871 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Seria Light Export Blend nhc | 36.4 | 0.843 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Stag Crude nhc | 18.4 | 0.944 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Straight Run Fuel Oil heated | 16 | 0.959 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| Su Tu Den Crude heated | 36.2 | 0.844 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Sumatran Light Crude Oil nhc | 34.6 | 0.852 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Tapis Blend Crude nhc | 45.8 | 0.798 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Varanus Crude nhc | 47.3 | 0.791 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Wandoo Crude nhc | 19.4 | 0.938 | | | ok 2015 | ok 2015 | ok 20 years | ok 2015 | |
| West Seno Crude nhc | 41 | 0.820 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Widuri Crude heated | 32.8 | 0.861 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |
| Woollybutt Crude nhc | 48.6 | 0.786 | ok 2015 | ok 2015 | ok 2015 | ok 2015 | ok 20 years | ok 2015 | ok |

| ANALYSIS | | Australia | Honk Kong | India | Japan | China | Singapore | South Korea |
|---|---|---|---|---|---|---|---|---|
| Number of Cargoes Available | | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Cargoes Carried until Phase out Date | | 44 | 44 | 60 | 60 | 60 | 60 | 44 |
| Percentage (%) | | 73.3% | 73.3% | 100.0% | 100.0% | 100.0% | 100.0% | 73.3% |
| Phase out Date | | 2015 | 2015 | 2015 | 2015 | 2012 | 2015 | No Date |
| Number of Cargoes Available | | 60 | 60 | 60 | 60 | 60 | 60 | 60 |

Sources: 1. International Maritime Organization, (2006), *Oil tankers regulation 20/21 implementation*, http://www.imo.org 2. Intertanko, (2006), *Flag and Port State Policies Implementation policies*, http://www.intertanko.com

# APPENDIX 11 CONVERSION COST ESTIMATION FOR EACH OPTION

| **CONVERSION OPTIONS** | **OPTION A** | | | **OPTION B** | | |
|---|---|---|---|---|---|---|
| | **Unit** | **Cost** | **US $** | **Unit** | **Cost** | **US $** |
| COTks Hand Cleaning | 30,000 | 2 | 60000 | 30,000 | 2 | 60000 |
| Steel Works | 1600000 | 1.32 | 2112000 | 2300000 | 1.32 | 3036000 |
| Relocation of cargo pipes d600 (60% of the Cost) | 500 | 420 | 210000 | 500 | 420 | 210000 |
| New Void Space Piping | | | 50000 | | | 40000 |
| Modify cargo control room Est. | | | 50000 | | | 30000 |
| Install new control lines for valves<br>Install new lines for new valves<br>Install gas detection pipes in W.B.Tks - Void Space | | | 50000 | | | 50000 |
| Ullages new callibration - new software etc. | | | 25000 | | | 25000 |
| Relocation of deck air vents Est. | | | 15000 | | | 15000 |
| Relocation of heating coils | 2560 | 15 | 38400 | 2560 | 15 | 38400 |
| Chemical Cleaning | 15200 | 4 | 60800 | 15200 | 4 | 60800 |
| Spotblasting of DB WB New parts | 4560 | 14 | 63840 | 4560 | 14 | 63840 |
| Blasting of remaining original parts | 15200 | 14 | 212800 | 15200 | 14 | 212800 |
| Coating of DB WBTksb (Ex Bottom) | 15200 | 2.3 | 34960 | 30400 | 2.3 | 69920 |
| COTks Tk top spotblast 20% | 1920 | 14 | 26880 | 1920 | 14 | 26880 |
| COTks Tk top coating bottom 1m. | 9600 | 2 | 19200 | 9600 | 2 | 19200 |
| Tks Bottom Scraping of oily areas /cleaning | 10000 | 5 | 50000 | 10000 | 5 | 50000 |
| Tks Botom Chemical cleaning + washing | 9600 | 4 | 38400 | 9600 | 4 | 38400 |
| Blasting of bottom plate (1200 x 8) | 9600 | 14 | 134400 | 9600 | 14 | 134400 |
| Coating of same (2 coats) | 32000 | 1 | 32000 | 32000 | 1 | 32000 |
| Paint Cost Estimation | (1 Coat in Void Spaces)* | | 65000 | | | 75000 |
| Blast/Paint of new b/hds W.B. sides 6200m2 | | | | | | 90,000 |
| Butterworth holes | | | | 30 | 500 | 15000 |
| Butterworth Machines | | | | 10 | 3000 | 30000 |
| Remote Sounding Supply and Install | | | | | | 40000 |
| New Tanks Pipe Work | | | | | | 70000 |
| New Tanks Accesses | | | | | | 35000 |
| New Tanks Heating Coils | | | | | | 50000 |
| New P/V Valves | | | | | | 10000 |
| Relocation of W.B Pipes | | | | | | 120000 |
| Void Tanks Accesses and Vents | | | 100000 | | | |
| **TOTAL** | | | **3448680** | | | **4747640** |

*Note: In the void space there is a reduced painting work scope as only one coat of paint is applied.

Source: Astron Maritime, Phoenix Energy Navigation, (2005, 2006), Prices based on quotations received from Shipyards for the Dry-docking of MT Compass I, MT Sentosa Spirit. MT Seraya Spirit, MT Seletar Spirit, MT Semacau Spirit, MV Arisbe, MV Astron Spirit. Private and Confidential.

# APPENDIX 12 VESSEL HISTORIC AVERAGE LIFETIME

| Main vessel type | Size range | Historical average lifetime (years) |
|---|---|---|
| Oil tanker | >200,000 DWT | 23.9 |
| | 120-200,000 DWT | 23.9 |
| | 80-120,000 DWT | 24.3 |
| | 60-80,000 DWT | 26.7 |
| | 40-60,000 DWT | 27.5 |
| | <40,000 DWT | 28.3 |
| | All | 26.1 |
| Other tanker | >200,000 DWT | 23.9* |
| | 120-200,000 DWT | 23.9* |
| | 80-120,000 DWT | 24.3* |
| | 60-80,000 DWT | 26.7* |
| | 40-60,000 DWT | 27.5* |
| | <40,000 DWT | 28.3* |
| | All | 26.1* |
| Bulk carrier | >80,000 DWT | 23.6 |
| | 60-80,000 DWT | 24.5 |
| | 40-60,000 DWT | 25.1 |
| | <40,000 DWT | 26.6 |
| | All | 25.7 |
| Container | >60,000 DWT | 24.9* |
| | 40-60,000 DWT | 24.9 |
| | 20-40,000 DWT | 25.4 |
| | <20,000 DWT | 25.5 |
| | All | 25.4 |
| Gas | >30,000 DWT | 28.4 |
| | 10-30,000 DWT | 31.4 |
| | <10,000 DWT | 28.7 |
| | All | 29.3 |
| Passenger/ro-ro/vehicle | >10,000 DWT | 22.5 |
| | 5-10,000 DWT | 28.4 |
| | <5,000 DWT | 28.6 |
| | All | 27.1 |
| Other cargo vessel | >40,000 DWT | 26.1 |
| | 20-40,000 DWT | 24.5 |
| | 10-20,000 DWT | 25.7 |
| | <10,000 DWT | 27.1 |
| | All | 25.9 |
| Non-cargo vessel | >40,000 DWT | 27.7* |
| | 20-40,000 DWT | 27.7* |
| | 10-20,000 DWT | 27.7* |
| | <10,000 DWT | 27.7 |
| | All | 27.7* |

Note: A * indicated that the numbers is not solely based on the mathematical average. Corrections have been for the segments with only few observations

Source: General Energy and Transport, (2004), *Oil Tanker Phase Out and the Ship Scrapping Industry*, European Commission, Brussels.

# APPENDIX 13 LIFE EXTENSION COST ESTIMATION

| PRINCESS | Unit | Cost | US $ |
|---|---|---|---|
| **A. W.B.Tks (Total volume 40,000 m3)** | | | |
| Staging 40,000 m3 | 40,000 | 2 | 80000 |
| Steel Renewals 50 t | 50000 | 1.42 | 71000 |
| Power Tool | 8000 | 8.00 | 64000 |
| Coating (stripe + 2 coats) 8,000m2 | | | 30000 |
| W.B.Tks pipe renewals | 50 | 600 | 30000 |
| Ballast line valves o/haul (est) | | | 15000 |
| Paints Cost Est | | | 80000 |
| A. Total | | | 370000 |
| **E. Conversion of No6 Ballast into Fuel** | | | |
| H.P. washing | 8000 | 3 | 24000 |
| Heating Coils installation | 200 | 60 | 12000 |
| Piping Modifications | | | 6000 |
| Chipping Rusty Spots | | | 12000 |
| E. Total | | | 54000 |
| **F. Conversion of No1 Fuel into Ballast** | | | |
| Chemical Cleaning/ Washing | 3400 | 4 | 13600 |
| Blasting + Coating | 3400 | 14 | 47600 |
| Stagin (800m3 x 2) | 1600 | 2 | 3200 |
| Long Bulkheadb (if fitted) | 80000 | 1.35 | 108000 |
| Piping Modifications | | | 20000 |
| F. Total | | | 192400 |
| **TOTAL** | | | **616400** |

| **CINDERELLA** | **Unit** | **Cost** | **US $** |
|---|---|---|---|
| **A. W.B.Tks (Total volume 40,000 m3)** | | | |
| Staging 40,000 m3 | 40,000 | 2 | 80000 |
| Rust Scale chipping 200m2/tk x 20tks = 4,000m2 | 4000 | 5 | 20000 |
| Steel Renewals 250 t | 250000 | 1.35 | 337500 |
| Spotblasting 80,000m2 x 35% | 28,000 | 14 | 392000 |
| Coating (stripe + 2 coats) 40,000m2 | 92000 | 1 | 92000 |
| W.B.Tks pipe renewals | 50 | 600 | 30000 |
| Ballast line valves o/haul (est) | | | 15000 |
| Paints Cost Est | | | 200000 |
| A. Total | | | 1166500 |
| **B. C.O.Tks Bottom** | | | |
| Tks Bottom Scraping of oily areas /cleaning | 10000 | 5 | 50000 |
| Tks Botom Chemical cleaning + washing | 9600 | 4 | 38400 |
| Blasting of bottom plate (1200 x 8) | 9600 | 14 | 134400 |
| Coating of same (2 coats) | 32000 | 1 | 32000 |
| B. Total | | | 254800 |
| **C. C.O.Tks Underdeck** | | | |
| Staging 90,000 m3 | 90000 | 2 | 180000 |
| Scraping 8,000 m2 x 2 (Est) | 8000 | 2 | 16000 |
| Chemical cleaning 18,000 m2 | 18000 | 3 | 54000 |
| Washing (included in the above) | | | |
| Steel Renewals 250 t x 1.35 | 250000 | 1.35 | 337500 |
| Coating (stripe + 2 coats) | 18000 | 2.3 | 41400 |
| Paints Cost Est | | | 50000 |
| C. Total | | | 678900 |
| **D. Anti-Fatigue Brackets** | | | |
| 1200 pcs 650x650x14 | 60000 | 1.35 | 81000 |
| **E. Conversion of No6 Ballast into Fuel** | | | |
| H.P. washing | 8000 | 3 | 24000 |
| Heating Coils installation | | | 12000 |
| Piping Modifications | | | 6000 |
| E. Total | | | 42000 |
| **F. Conversion of No1 Fuel into Ballast** | | | |
| Chemical Cleaning/ Washing | 3400 | 4 | 13600 |
| Blasting + Coating | 3400 | 14 | 47600 |
| Staging (800m3 x 2) | 1600 | 2 | 3200 |
| Long Bulkheadb (if fitted) | 70000 | 1.35 | 94500 |
| Piping Modifications | | | 20000 |
| F. Total | | | 178900 |
| **TOTAL** | | | **2402100** |

Source: Astron Maritime, Phoenix Energy Navigation, (2005, 2006), Prices based on quotations received from Shipyards for the Dry-docking of MT Compass I, MT Sentosa Spirit. MT Seraya Spirit, MT Seletar Spirit, MT Semacau Spirit, MV Arisbe, MV Astron Spirit. Private and Confidential.

# APPENDIX 14 NORMAL DOCKING WORKS COST ESTIMATION

| PRINCESS | Unit | Cost | Disc. | US $ |
|---|---|---|---|---|
| **1.1 Slops** | | | | |
| Removal 500 tones of slops | 500 | 50 | 0.58 | 14500 |
| Removal 100 tones of sludge | 150 | 120 | 0.58 | 10440 |
| Man/hour | | | | |
| Overtime Man/hour | | | | |
| Extra charge per ton | | | | |
| Additional Costs | | | | |
| **1.0 Sub Total** | | | | **24940** |
| **2.1 Pilot** | | | | |
| Arrival | 1 | 600.00 | 0.58 | 348 |
| Departure | 1 | 600.00 | 0.58 | 348 |
| Per Shift | 4 | 600.00 | 0.58 | 1392 |
| 2.1 Total | | | | 2088 |
| **2.2 Mooring Tugs** | | | | |
| Arrival | 1 | 4700.00 | 0.58 | 2726 |
| Departure | 1 | 4700.00 | 0.58 | 2726 |
| Per Shift | 4 | 4700.00 | 0.58 | 10904 |
| 2.2 Total | | | | 16356 |
| **2.0 Sub Total** | | | | **18444** |
| **3.1 Line Handlers and Riggers** | | | | |
| Arrival | 1 | 500 | 0.58 | 290 |
| Departure | 1 | 500 | 0.58 | 290 |
| Unit Price per Shift | 2 | 500 | 0.58 | 580 |
| Additional overtime | | | | |
| Additional Sunday / Holliday | | | | |
| 3.1 Total | | | | 1160 |
| **3.2 Windlass & Mooring Winches** | | | | |
| Operate Windlass and Winches | Free | | | |
| Cost for connect/disconnect | Free | | | |
| Cost per day including fuel/ maintenance | Free | | | |
| **3.3 Gas Free Certificate** | | | | |
| Price for first visit | 1 | 80 | 0.58 | 46.4 |
| Additional Visit 120 days | 120 | 40 | 0.58 | 2784 |
| Hot Work Permit | | | | |
| 3.3 Total | | | | 2830.4 |
| **3.4 Fire Main** | | | | |
| Connection & disconnection | 4 | 40 | 0.58 | 92.8 |
| Maintain Pressure | 120 | 20 | 0.58 | 1392 |
| 3.4 Total | | | | 1484.8 |
| **3.5 Fire Watchman** | | | | |
| Daily | 120 | 120 | 0.58 | 8352 |
| Security | | | | |
| **3.6 Cooling Water** | | | | |
| Connection & disconnection | 8 | 40 | 0.58 | 185.6 |
| Supply per day | 240 | 40 | 0.58 | 5568 |
| 3.6 Total | | | | 5753.6 |

| | | | | |
|---|---|---|---|---|
| **3.7 Steam Supply** | | | | |
| Connection & disconnection | Not Available | | | |
| Supply per day 10 days DD | Not Available | | | |
| **3.8 Electric Power Supply** | | | | |
| Connection & disconnection | 4 | 100 | 0.58 | 232 |
| Supply per kw 60000kwh | 624000 | 0.2 | | 124800 |
| 3.8 Total | | | | 125032 |
| **3.9 Accommodation Electric Heaters** | | | | |
| Connection & disconnection | | | | |
| Heater / day | | CANCEL | | |
| 30 heaters / day | | | | |
| **3.10 Fresh Water** | | | | |
| Connection & disconnection | 4 | 40 | 0.58 | 92.8 |
| Supply per ton | 2000 | 1 | 0.58 | 1160 |
| 3.10 Total | | | | 1252.8 |
| **3.11 Ballast Water** | | | | |
| Connection & disconnection | 10 | 40 | 0.58 | 232 |
| Supply per ton 40000 | 40000 | 0.4 | 0.58 | 9280 |
| 3.11 Total | | | | 9512 |
| **3.12 Garbage Removal** | | | | |
| Daily | 120 | 30 | 0.58 | 2088 |
| **3.13 Crane Services** | | | | |
| Price per hour | 50 | 60 | 0.58 | 1740 |
| Price per hour for rigging gang | | | | |
| **3.14 Bottom Plugs** | | | | |
| Remove | 20 | 20 | 0.58 | 232 |
| Vacuum test | | | | |
| **3.15 Engine room access hatches** | | | | |
| Engine room access H/C 2x3m | 2 | 250 | 0.58 | 290 |
| Pump room access H/C 2x3m | 2 | 250 | 0.58 | 290 |
| 3.15 Total | | | | 580 |
| **3.16 Cargo Manifold** | | | | |
| 8 pressure gauges | 10 | 80 | 0.58 | 464 |
| 15 temp thermometers | 16 | 80 | 0.58 | 742.4 |
| 3.16 Total | | | | 1206.4 |
| **3.17 Dock Trials** | | | | |
| Mooring Trial 6 hours | 6.5 | 800 | 0.58 | 3016 |
| **3.18 Sea Trials** | | | | |
| Trials | 0 | 800 | 0.58 | 0 |
| **3.19 Telephone** | | | | |
| Communication Est. | | | | 5000 |
| **3.20 Toilet/Sewage/Shower** | | | | |
| Connect disconnect | 10 | 100 | 0.58 | 580 |
| Per Day | 120 | 100 | 0.58 | 6960 |
| 3.20 Total | | | | 7540 |
| **3.21 Gangway** | | | | |
| Per piece | 3 | 800 | 0.58 | 1392 |
| **3.22 Additional services** | | | | |
| Additional | | | | |
| **3.23 Engine room bilges** | | | | |
| Pump Out and Disposal per ton | 100 | 50 | 0.58 | 2900 |
| **3.24 Dry-docking** | | | | |
| Tugboats | 2 | 5200 | 0.58 | 6032 |

| | | | | |
|---|---|---|---|---|
| Riggers | 2 | 600 | 0.58 | 696 |
| Pilot | 2 | 800 | 0.58 | 928 |
| DD Dues first two days | 1 | 22000 | 0.58 | 12760 |
| DD Dues remaining days | 6 | 6000 | 0.58 | 20880 |
| 3.24 Total | | | | 41296 |
| **3.25 Heaters for Electric Motors** | | | | |
| 15 off heaters per day per set | 150 | 5 | 0.58 | 500 |
| **3.26 Protection of Machinery** | | | | |
| Machinery Protection Estimate | | | | 500 |
| **3.27 Compressed Air Supply** | | | | |
| Connection & disconnection | 8 | 40 | 0.58 | 185.6 |
| Supply for crew service | 78 | 40 | 0.58 | 1809.6 |
| 3.27 Total | | | | 1995.2 |
| **3.28 Safety Guard Rails** | | | | |
| Test | | | | |
| **3.0 Sub Total** | | | | **225363.2** |
| **4.1 Scupper Overboard Discharge** | | | | |
| Discharge Extensions | 35 | 20 | 0.58 | 406 |
| **4.2 Oil and Grease Removal** | | | | |
| Remove 600m2 | 600 | 4 | 0.58 | 1392 |
| **4.3 FW Washing - Blasting - Touch up** | | | | |
| HP FW Washing | 17280 | 0.6 | 0.58 | 6100 |
| LP FW Washing | 17280 | 0.3 | 0.58 | 3100 |
| S.A 2.5 | 5184 | 6 | | 31104 |
| Touch up 50% Area twice | 17280 | 0.48 | | 8294 |
| 4.3 Total | | | | 48598.4 |
| **4.4 Flat Bottom - 5750 m2** | | | | |
| Coating | 5750 | 0.9 | | 5175 |
| **4.5 Vertical bottom - 8280 m2** | | | | |
| Coating | 16560 | 0.9 | | 14904 |
| **4.6 Topside - 3150 m2** | | | | |
| Coating | 3150 | 0.9 | | 2835 |
| 4.4-4.5-4.6 Total Coating | | | | 22914 |
| **4.7 Vessel's Name & Marking** | | | | |
| Ships Name & Port of registry | | | | |
| plimsol, drafts & bulbous marks | | | | |
| IMO number | | | | |
| Tanks | | | | |
| Estimate | | | | 2800 |
| **4.0 Sub Total** | | | | **76110.4** |
| **5.1 Rudder and Rudder Pintle** | | | | |
| Rudder trunk access manhole | 1 | 200 | 0.58 | 116 |
| Bearing clearances | 1 | 150 | 0.58 | 87 |
| Remove/refit pintle access covers | 1 | 180 | 0.58 | 104.4 |
| Pintle clearances remove nuts and re-cement | 1 | 300 | 0.58 | 174 |
| Rudder stock gland renew | 1 | 150 | 0.58 | 87 |
| Rudder plug remove/refit/test | 1 | 50 | 0.58 | 29 |
| Staging | 1 | 120 | 0.58 | 69.6 |
| Allowance | | | | 333 |
| 5.1 Total | | | | 1000 |
| **5.2 Rudder Pintle Unit Prices** | | | | |
| Remove upper pintle bearing supply new | | | | |
| Remove upper pintle sleeve supply new | | | | |

| | | | | |
|---|---|---|---|---|
| Remove upper pintle sleeve machine<br>Remove lower pintle bearing supply new<br>Remove lower pintle sleeve supply new<br>Remove lower pintle sleeve machine<br>Staging<br>Estimate | | | | 4000 |
| **5.3 Shaft** | | | | |
| Tailshaft removal renew gaskets<br>Wear down<br>Propeller removal<br>Tailshaft survey estimate | | | | 8000 |
| **5.4 Stern Tube Seals** | | | | |
| Seal Boxes renew seals | 2 | 1000.00 | 0.58 | 1160 |
| Machine liners | 2 | 1200.00 | 0.58 | 1392 |
| Checking | 1 | 800.00 | 0.58 | 464 |
| Renew Zink anodes | 1 | 100.00 | 0.58 | 58 |
| 5.4 Total | | | | 3074 |
| **5.5 Anchor and Anchor Chains** | | | | |
| Lower anchor chains/inspect/gauge stow back | 2 | 1600.00 | 0.58 | 1856 |
| Grit Sweep measurements taken | 2 | 1200.00 | 0.58 | 1392 |
| Examine D shackle | 2 | 50.00 | 0.58 | 58 |
| Mark with copper wire | | | 0.58 | 0 |
| Weld loose studs | 25 | 30.00 | 0.58 | 435 |
| Disconnect anchor bitter ends | 2 | 150.00 | 0.58 | 174 |
| Chain Locker cleaning fish oil | 2 | 800.00 | 0.58 | 928 |
| Remove chain locker strainers | 2 | 1200.00 | 0.58 | 1392 |
| Remove mud | 10 | 200.00 | 0.58 | 1160 |
| Disassemble bilge ejectors assemble test | 2 | 600.00 | 0.58 | 696 |
| Allowance | | | | 909 |
| 5.5 Total | | | | 9000 |
| **5.6 Propeller** | | | | |
| Check and Polish at DD | 1 | 1600.00 | 0.58 | 928 |
| Check blade edges for cracks | 1 | 350.00 | 0.58 | 203 |
| Ground smooth blade edges | 1 | 1000.00 | 0.58 | 580 |
| Cover with grease during painting Est. | | | | 300 |
| Allowance | | | | 289 |
| 5.5 Total | | | | 2300 |
| **5.7 Sea chest and sea chest anodes** | | | | |
| Overhauling | 4 | 400.00 | 0.58 | 1000 |
| **5.8 Sea Valves** | | | | |
| Estimate | | | | 7000 |
| **5.9 Sea Valves Pump Room** | | | | |
| Estimate | | | | 3200 |
| **5.10 Anodes Protection** | | | | |
| Estimate | | | | 1400 |
| **5.0 Sub Total** | | | | **39974** |
| **6.1 ME Air Coolers** | | | | |
| Overhaul | 1 | 2200 | 0.58 | 1276 |
| **6.2 ME Pistons** | | | | |
| Piston O/h | | | | 12000 |
| **6.3 ME Injection Systems** | | | | |
| Injection System O/h | | | | 8000 |
| **6.4 ME Automation** | | | | |

| | |
|---|---|
| Automation O/h | 10000 |
| **6.0 Sub Total** | **31276** |
| **7.1 Main Boiler Survey** | |
| Boiler Overhaul<br>Mounting Valve O/h<br>Boiler Survey Est. | 10000 |
| **7.2 Exhaust Gas Economiser** | |
| Economiser o/h<br>Mounting Valve O/h<br>EGE Economiser | 5000 |
| **7.0 Sub Total** | **15000** |
| **8.0 Electrical Equipment** | |
| Estimate | 10000 |
| **8.0 Sub Total** | **10000** |
| **9.1 ER Pipes** | |
| Estimate | 60000 |
| **9.2 DG's + Coolers + Aux. Machinery** | |
| Estimate | 12000 |
| **9.3 Main Deck Cargo Tank Pipes Dressor Couplings** | |
| Estimate | 7000 |
| **9.4 IGS Dressor Couplings** | |
| Estimate | 3000 |
| **9.5 - 9.6 - 9.7 Valves** | |
| 9.5 Main Deck Cross Over Valves<br>9.6 Stripping Line Cross Over Valves<br>9.7 Cargo Tank Valves<br>Estimate | 10000 |
| **9.7 Lifeboat Tests** | |
| Estimate | 5000 |
| **9.8 Air vents + PV Breaker o/h + PV Valves** | |
| Estimate | 10000 |
| **9.8 Cargo Gear, Mooring Winches Brakes, Load Test** | |
| Estimate | 20000 |
| **9.0 Sub Total** | **127000** |
| **10.0 DD Related Costs** | |
| Contractor-Spares services-Paints-Class Fees | 400000 |
| **TOTAL** | **968107.6** |

| CINDERELLA | Unit | Cost | Disc. | US $ |
|---|---|---|---|---|
| **1.1 Slops** | | | | |
| Removal 1000 tones of slops | 1000 | 50 | 0.58 | 29000 |
| Removal 100 tones of sludge | 150 | 120 | 0.58 | 10440 |
| Man/hour | | | | |
| Overtime Man/hour | | | | |
| Extra charge per ton | | | | |
| Additional Costs | | | | |
| **1.0 Sub Total** | | | | **39440** |
| **2.1 Pilot** | | | | |
| Arrival | 1 | 600.00 | 0.58 | 348 |
| Departure | 1 | 600.00 | 0.58 | 348 |
| Per Shift | 4 | 600.00 | 0.58 | 1392 |
| 2.1 Total | | | | 2088 |
| **2.2 Mooring Tugs** | | | | |
| Arrival | 1 | 4700.00 | 0.58 | 2726 |
| Departure | 1 | 4700.00 | 0.58 | 2726 |
| Per Shift | 4 | 4700.00 | 0.58 | 10904 |
| 2.2 Total | | | | 16356 |
| **2.0 Sub Total** | | | | **18444** |
| **3.1 Line Handlers and Riggers** | | | | |
| Arrival | 1 | 500 | 0.58 | 290 |
| Departure | 1 | 500 | 0.58 | 290 |
| Unit Price per Shift | 2 | 500 | 0.58 | 580 |
| Additional overtime | | | | |
| Additional Sunday / Holliday | | | | |
| 3.1 Total | | | | 1160 |
| **3.2 Windlass & Mooring Winches** | | | | |
| Operate Windlass and Winches | Free | | | |
| Cost for connect/disconnect | Free | | | |
| Cost per day including fuel/ maintenance | Free | | | |
| **3.3 Gas Free Certificate** | | | | |
| Price for first visit | 1 | 80 | 0.58 | 46.4 |
| Additional Visit 120 days | 120 | 40 | 0.58 | 2784 |
| Hot Work Permit | | | | |
| 3.3 Total | | | | 2830.4 |
| **3.4 Fire Main** | | | | |
| Connection & disconnection | 4 | 40 | 0.58 | 92.8 |
| Maintain Pressure | 120 | 20 | 0.58 | 1392 |
| 3.4 Total | | | | 1484.8 |
| **3.5 Fire Watchman** | | | | |
| Daily | 120 | 120 | 0.58 | 8352 |
| Security | | | | |
| **3.6 Cooling Water** | | | | |
| Connection & disconnection | 8 | 40 | 0.58 | 185.6 |
| Supply per day | 240 | 40 | 0.58 | 5568 |
| 3.6 Total | | | | 5753.6 |
| **3.7 Steam Supply** | | | | |
| Connection & disconnection | Not Available | | | |
| Supply per day 10 days DD | Not Available | | | |
| **3.8 Electric Power Supply** | | | | |
| Connection & disconnection | 4 | 100 | 0.58 | 232 |

| | | | | |
|---|---|---|---|---|
| Supply per kw 60000kwh | 624000 | 0.2 | | 124800 |
| 3.8 Total | | | | 125032 |
| **3.9 Accommodation Electric Heaters** | | | | |
| Connection & disconnection<br>heater / day<br>30 heaters / day | | CANCEL | | |
| **3.10 Fresh Water** | | | | |
| Connection & disconnection | 4 | 40 | 0.58 | 92.8 |
| Supply per ton | 2000 | 1 | 0.58 | 1160 |
| 3.10 Total | | | | 1252.8 |
| **3.11 Ballast Water** | | | | |
| Connection & disconnection | 10 | 40 | 0.58 | 232 |
| Supply per ton 40000 | 40000 | 0.4 | 0.58 | 9280 |
| 3.11 Total | | | | 9512 |
| **3.12 Garbage Removal** | | | | |
| Daily | 120 | 30 | 0.58 | 2088 |
| **3.13 Crane Services** | | | | |
| Price per hour | 50 | 60 | 0.58 | 1740 |
| Price per hour for rigging gang | | | | |
| **3.14 Bottom Plugs** | | | | |
| Remove | 20 | 20 | 0.58 | 232 |
| Vacuum test | | | | |
| **3.15 Engine Room Access Hatches** | | | | |
| Engine room access H/C 2x3m | 2 | 250 | 0.58 | 290 |
| Pump room access H/C 2x3m | 2 | 250 | 0.58 | 290 |
| 3.15 Total | | | | 580 |
| **3.16 Cargo Manifold** | | | | |
| 8 pressure gauges | 10 | 80 | 0.58 | 464 |
| 15 temp thermometers | 16 | 80 | 0.58 | 742.4 |
| 3.16 Total | | | | 1206.4 |
| **3.17 Dock Trials** | | | | |
| Mooring Trial 6 hours | 6.5 | 800 | 0.58 | 3016 |
| **3.18 Sea Trials** | | | | |
| Trials | 0 | 800 | 0.58 | 0 |
| **3.19 Telephone** | | | | |
| Communication Est. | | | | 5000 |
| **3.20 Toilet/Sewage/Shower** | | | | |
| Connection & disconnection | 10 | 100 | 0.58 | 580 |
| Per Day | 120 | 100 | 0.58 | 6960 |
| 3.20 Total | | | | 7540 |
| **3.21 Gangway** | | | | |
| Per piece | 3 | 800 | 0.58 | 1392 |
| **3.22 Additional Services** | | | | |
| Additional | | | | |
| **3.23 Engine Room Bilges** | | | | |
| Pump Out and Disposal per ton | 100 | 50 | 0.58 | 2900 |
| **3.24 Dry-Docking** | | | | |
| Tugboats | 2 | 5200 | 0.58 | 6032 |
| Riggers | 2 | 600 | 0.58 | 696 |
| Pilot | 2 | 800 | 0.58 | 928 |
| DD Dues first two days | 1 | 22000 | 0.58 | 12760 |
| DD Dues remaining days | 6 | 6000 | 0.58 | 20880 |
| 3.24 Total | | | | 41296 |

| | | | | |
|---|---|---|---|---|
| **3.25 Heaters for Electric Motors** | | | | |
| 15 off heaters per day per set | 150 | 5 | 0.58 | 500 |
| **3.26 Protection of Machinery** | | | | |
| Machinery Protection Est. | | | | 500 |
| **3.27 Compressed Air Supply** | | | | |
| Connection & disconnection | 8 | 40 | 0.58 | 185.6 |
| Supply for crew service | 78 | 40 | 0.58 | 1809.6 |
| 3.27 Total | | | | 1995.2 |
| **3.0 Sub Total** | | | | **225363.2** |
| **4.1 Scupper overboard Discharge** | | | | |
| Discharge extensions | 35 | 20 | 0.58 | 406 |
| **4.2 Oil and Grease Removal** | | | | |
| Remove 600m2 | 600 | 4 | 0.58 | 1392 |
| **4.3 FW Washing - Blasting - Touch Up** | | | | |
| HP FW Washing | 17280 | 0.6 | 0.58 | 6100 |
| LP FW Washing | 17280 | 0.3 | 0.58 | 3100 |
| S.A 2.5 | 5184 | 6 | | 31104 |
| Touch up 50% Area twice | 17280 | 0.48 | | 8294 |
| 4.3 Total | | | | 48598.4 |
| **4.4 Flat bottom - 5750 m2** | | | | |
| Coating | 5750 | 0.9 | | 5175 |
| **4.5 Vertical bottom - 8280 m2** | | | | |
| Coating | 16560 | 0.9 | | 14904 |
| **4.6 Topside - 3150 m2** | | | | |
| Coating | 3150 | 0.9 | | 2835 |
| 4.4-4.5-4.6 Total Coating | | | | 22914 |
| **4.7 Vessel's Name & Marking** | | | | |
| Ships Name & Port of registry | | | | |
| Plimsoll, drafts & bulbous marks | | | | |
| IMO number | | | | |
| Tanks | | | | |
| Estimate | | | | 2800 |
| **4.0 Sub Total** | | | | **76110.4** |
| **5.1 Rudder and Rudder Pintle** | | | | |
| Rudder trunk access manhole | 1 | 200 | 0.58 | 116 |
| Bearing clearances | 1 | 150 | 0.58 | 87 |
| Remove/refit pintle access covers | 1 | 180 | 0.58 | 104.4 |
| Pintle clearances remove nuts and re-cement | 1 | 300 | 0.58 | 174 |
| Rudder stock gland renew | 1 | 150 | 0.58 | 87 |
| Rudder plug remove/refit/test | 1 | 50 | 0.58 | 29 |
| Staging's | 1 | 120 | 0.58 | 69.6 |
| Allowance | | | | 333 |
| 5.1 Total | | | | 1000 |
| **5.2 Rudder Pintle unit prices** | | | | |
| Remove upper pintle bearing supply new | | | | |
| Remove upper pintle sleeve supply new | | | | |
| Remove upper pintle sleeve machine | | | | |
| Remove lower pintle bearing supply new | | | | |
| Remove lower pintle sleeve supply new | | | | |
| Remove lower pintle sleeve machine | | | | |
| Staging | | | | |
| Rudder Pintle Work Estimate | | | | 4000 |
| 5.2 Total | | | | 4000 |

| | | | | |
|---|---|---|---|---|
| **5.3 Shaft** | | | | |
| Tailshaft removal renew gaskets | | | | |
| Wear down | | | | |
| Propeller removal | | | | |
| Tailshaft survey estimate | | | | 8000 |
| 5.3Total | | | | 8000 |
| **5.4** | | | | |
| Seal Boxes renew seals | 2 | 1000.00 | 0.58 | 1160 |
| Machine liners | 2 | 1200.00 | 0.58 | 1392 |
| Checking | 1 | 800.00 | 0.58 | 464 |
| Renew Zink anodes | 1 | 100.00 | 0.58 | 58 |
| 5.4 Total | | | | 3074 |
| **5.5 Anchor and Anchor Chains** | | | | |
| Lower anchor chains/inspect/gauge stow back | 2 | 1600.00 | 0.58 | 1856 |
| Grit Sweep measurements taken | 2 | 1200.00 | 0.58 | 1392 |
| Examine D shackle | 2 | 50.00 | 0.58 | 58 |
| Mark with copper wire | | | 0.58 | 0 |
| Weld loose studs | 25 | 30.00 | 0.58 | 435 |
| disconect anchor bitter ends | 2 | 150.00 | 0.58 | 174 |
| Chain Locker cleaning fish oil | 2 | 800.00 | 0.58 | 928 |
| Remove chain locker strainers | 2 | 1200.00 | 0.58 | 1392 |
| Remove mud | 10 | 200.00 | 0.58 | 1160 |
| Disassemble bilge ejectors assemble test | 2 | 600.00 | 0.58 | 696 |
| Allowance | | | | 909 |
| 5.5 Total | | | | 9000 |
| **5.6 Propeller** | | | | |
| Check and Polish at DD | 1 | 1600.00 | 0.58 | 928 |
| Check blade edges for cracks | 1 | 350.00 | 0.58 | 203 |
| Ground smooth blade edges | 1 | 1000.00 | 0.58 | 580 |
| Cover with grease during painting Est. | | | | 300 |
| Allowance | | | | 289 |
| 5.5 Total | | | | 2300 |
| **5.7 Sea Chest and Sea Chest Anodes** | | | | |
| Overhauling | 4 | 400.00 | 0.58 | 1000 |
| **5.8 Sea Valves** | | | | |
| Estimate | | | | 7000 |
| **5.9 Sea Valves Pump Room** | | | | |
| Estimate | | | | 3200 |
| **5.10 Anodes Protection** | | | | |
| Estimate | | | | 1400 |
| **5.0 Sub Total** | | | | **39974** |
| **6.1 ME Air Coolers** | | | | |
| Overhaul | 1 | 2200 | 0.58 | 1276 |
| **6.2 ME Pistons** | | | | |
| Piston O/h | | | | 12000 |
| **6.3 ME Injection Systems** | | | | |
| Injection System O/h | | | | 8000 |
| **6.4 ME Automation** | | | | |
| Automation O/h | | | | 10000 |
| **6.0 Sub Total** | | | | **31276** |
| **7.1 Main Boiler Survey** | | | | |
| Boiler Overhaul | | | | |
| Mounting Valve O/h | | | | |

| | |
|---|---|
| Boiler Survey Est. | 10000 |
| **7.2 Exhaust Gas Economiser** | |
| Economiser o/h<br>Mounting Valve O/h<br>EGE Economiser | <br><br>5000 |
| **7.0 Sub Total** | **15000** |
| **8.0 Electrical Equipment** | |
| Estimate | 10000 |
| **8.0 Sub Total** | **10000** |
| **9.1 ER Pipes** | |
| Estimate | 60000 |
| **9.2 DG's + Coolers + Aux. Machinery** | |
| Estimate | 12000 |
| **9.3 Main Deck Cargo Tank Pipes Dressor Couplings** | |
| Estimate | 7000 |
| **9.4 IGS Dressor Couplings** | |
| Estimate | 3000 |
| **9.5 - 9.6 - 9.7 Valves** | |
| 9.5 Main Deck Cross Over Valves<br>9.6 Stripping Line Cross Over Valves<br>9.7 Cargo Tk Valves<br>Estimate | <br><br><br>10000 |
| **9.7 Lifeboat Tests** | |
| Estimate | 5000 |
| **9.8 Air vents + PV breaker o/h + PV valves** | |
| Estimate | 10000 |
| **9.8 Cargo Gear, Mooring Winches Brakes, Load Test** | |
| Estimate | 20000 |
| **9.0 Sub Total** | **127000** |
| **10.0 DD Related Costs** | |
| Contractor-Spairs services-Paints-Class Fees | 400000 |
| **TOTAL** | **982607.6** |

Sources: 1. Astron Maritime, Phoenix Energy Navigation, (2005, 2006), Prices based on quotations received from Shipyards for the Dry-docking of MT Compass I, MT Sentosa Spirit. MT Seraya Spirit, MT Seletar Spirit, MT Semacau Spirit, MV Arisbe, MV Astron Spirit. Private and Confidential.

2. Astron Maritime, Phoenix Energy Navigation (2005, 2006), Specifications prepared for the Dry-docking of MT Compass I, MT Sentosa Spirit. MT Seraya Spirit, MT Seletar Spirit, MT Semacau Spirit, MV Arisbe, MV Astron Spirit. Private and Confidential.

# APPENDIX 15 PACIFIC BASIN AFFRAMAX VESSELS PARCELS & VOYAGES IN 2006

| VESSEL | VOYAGE | LOAD PORT | LOAD DATE | GRADE | QUANTITY MT | DISCHARGE PORT | DISCHARGE DATE | SG | $M^3$ |
|---|---|---|---|---|---|---|---|---|---|
| VESSEL A | 131 | DAMPIER | 1/14/2004 | NWS CONDENSATE | 79,572.30 | YOSU | 2/1/2004 | 0.738 | 107821.5447 |
| | | | | | **79572.3** | | | | **107821.54** |
| VESSEL A | 132 | SANTAN | 2/10/2004 | ATTAKA CRUDE | 19,231.42 | YOSU | 2/27/2004 | 0.809 | 23771.84054 |
| VESSEL A | 132 | SANTAN | 2/10/2004 | WEST SENO CRUDE | 25,892.59 | YOSU | 2/28/2004 | 0.82 | 31576.32561 |
| VESSEL A | 132 | DUMAI | 2/16/2004 | DURI CRUDE | 44,556.05 | YOSU | 2/28/2004 | 0.928 | 48012.98491 |
| | | | | | **89680.056** | | | | **103361.15** |
| VESSEL A | 133 | JEBEL DHANNA | 3/18/2004 | MURBAN CRUDE | 90,824.00 | KWINANA | 4/5/2004 | 0.826 | 109956.4165 |
| | | | | | **90824** | | | | **109956.42** |
| VESSEL A | 134 | BLANG LANCANG | 4/16/2004 | ARUN CONDENSATE | 22,593.00 | SRIRACHA | 5/2/2004 | 0.749 | 30164.21896 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VESSEL A | 134 | SERIA | 4/20/2004 | SERIA LIGHT EXPORT BLEND | 38,481.00 | SRIRACHA | 5/2/2004 | 0.843 | 45647.68683 |
| VESSEL A | 134 | PLATONG | 4/25/2004 | PATTANI CRUDE | 12,898.71 | SRIRACHA | 5/2/2004 | 0.906 | 14229.60494 |
| | | | | | **73972.713** | | | | **90041.511** |
| VESSEL A | 135 | SERIA | 5/9/2004 | CHAMPION EXPORT CRUDE | 94,214.00 | WHANGAREI | 6/1/2004 | 0.883 | 106697.6217 |
| | | | | | **94214** | | | | **106697.62** |
| VESSEL A | 136 | BAYU UNDAN | 6/12/2004 | BAYU UNDAN CONDESATE | 44,420.92 | YOSU | 6/27/2004 | 0.727 | 61101.67538 |
| VESSEL A | 136 | MODEC VENTURE | 6/13/2004 | ELANG CRUDE | 33,793.51 | YOSU | 6/27/2004 | 0.751 | 44998.01598 |
| | | | | | **78214.428** | | | | **106099.69** |
| VESSEL A | 137 | HUIZHOU | 7/4/2004 | NANHAI CRUDE | 89,043.61 | BARBERS POINT | 7/24/2004 | 0.831 | 107152.3574 |
| | | | | | **89043.609** | | | | **107152.36** |
| VESSEL B | 164 | KERTEH | 2/10/2004 | TAPIS BLEND CRUDE | 75,874.66 | BRISBANE | 2/23/2004 | 0.798 | 95081.02506 |
| | | | | | **75874.658** | | | | **95081.025** |
| VESSEL B | 165 | SENIPAH | 3/27/2004 | HANDIL MIX | 9,460.80 | KWINANA | 4/9/2004 | 0.811 | 11665.59803 |

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|---|---|---|---|---|---|---|---|---|---|
| VESSEL B | 165 | SENIPAH | 3/27/2004 | BEKAPAI CRUDE | 10,538.40 | KWINANA | 4/9/2004 | 0.804 | 13107.46269 |
| VESSEL B | 165 | SENIPAH | 3/27/2004 | SENIPAH CONDENSATE | 49,321.90 | SINGAPORE | 8/17/2004 | 0.769 | 64137.71131 |
| VESSEL B | 165 | SANTAN | 3/27/2004 | BADAK CRUDE | 17,982.04 | KWINANA | 4/9/2004 | 0.823 | 21858.02742 |
| | | | | | **87303.14** | | | | **110768.8** |
| VESSEL B | 167 | KUMUL | 5/29/2004 | KUTUBU CRUDE | 82,141.00 | SAN FRANCISCO | 6/23/2004 | 0.804 | 102226.3611 |
| | | | | | **82141** | | | | **102226.36** |
| VESSEL C | 081 | LAMINARIA | 1/8/2004 | LAMINARIA CRUDE | 74,585.35 | YOSU | 1/19/2004 | 0.739 | 100940.5933 |
| | | | | | **74585.347** | | | | **100940.59** |
| VESSEL C | 082 | RANG DONG | 1/28/2004 | RANG DONG CRUDE | 47,766.71 | KWINANA | 2/11/2004 | 0.826 | 57828.95157 |
| VESSEL C | 082 | ARDJUNA | 2/2/2004 | ARDJUNA CRUDE | 29,483.00 | KWINANA | 2/11/2004 | 0.860 | 34275.28975 |
| | | | | | **77249.714** | | | | **92104.241** |
| VESSEL C | 083 | DAMPIER | 2/19/2004 | NWS CONDENSATE | 42,401.5000 | SINGAPORE | 3/2/2004 | 0.738 | 57454.60705 |
| VESSEL C | 083 | BLANG LANCANG | 2/28/2004 | ARUN CONDENSATE | 34,898.0000 | SINGAPORE | 3/2/2004 | 0.749 | 46592.79039 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **77299.5** | | | | **104047.4** |
| VESSEL C | 084 | KERTEH | 3/13/2004 | TAPIS BLEND CRUDE | 83,989.91 | SRIRACHA | 3/17/2004 | 0.798 | 105250.5175 |
| | | | | | **83989.913** | | | | **105250.52** |
| VESSEL C | 085 | DAMPIER | 3/29/2004 | NWS CONDENSATE | 75,828.07 | YOSU | 4/12/2004 | 0.738 | 102748.0623 |
| | | | | | **75828.07** | | | | **102748.06** |
| VESSEL C | 086 | SANTAN | 6/2/2004 | BADAK CRUDE | 43,114.03 | KWINANA | 6/15/2004 | 0.823 | 52407.16014 |
| VESSEL C | 086 | LAMINARIA | 6/7/2004 | LAMINARIA CRUDE | 38,415.19 | KWINANA | 6/16/2004 | 0.739 | 51989.46208 |
| | | | | | **81529.22** | | | | **104396.62** |
| VESSEL C | 087 | STAG | 6/24/2004 | STAG CRUDE | 29,810.48 | YOSU | 7/15/2004 | 0.944 | 31578.89831 |
| VESSEL C | 087 | BUFFALO VENTURE | 7/3/2004 | BUFFALO CRUDE | 53,917.94 | YOSU | 7/15/2004 | 0.944 | 57116.46186 |
| | | | | | **83728.42** | | | | **88695.36** |
| VESSEL C | 088 | SU TU DEN | 7/26/2004 | SU TU DEN CRUDE | 86,850.49 | BARBERS POINT | 8/18/2004 | 0.844 | 102903.423 |
| | | | | | **86850.489** | | | | **102903.42** |

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|---|---|---|---|---|---|---|---|---|---|
| VESSEL D | 074 | RAS TANURA | 2/8/2004 | ARABIAN MEDIUM CRUDE | 70,826.42 | KWINANA | 3/1/2004 | 0.882 | 80302.06349 |
| VESSEL D | 074 | JEBEL DHANNA | 2/10/2004 | MURBAN CRUDE | 25,060.00 | KWINANA | 3/1/2004 | 0.826 | 30338.98305 |
| | | | | | **95886.42** | | | | **110641.05** |
| VESSEL D | 075 | STAG | 3/9/2004 | STAG CRUDE | 36,064.06 | IWAKUNI | 3/28/2004 | 0.944 | 38203.45339 |
| VESSEL D | 075 | WANDOO | 3/13/2004 | WANDOO CRUDE | 14,888.560 | IWAKUNI | 3/28/2004 | 0.938 | 15872.66525 |
| VESSEL D | 075 | SERIA | 3/21/2004 | SERIA LIGHT EXPORT BLEND | 37,931.000 | IWAKUNI | 3/28/2004 | 0.843 | 44995.25504 |
| | | | | | **88883.62** | | | | **99071.374** |
| VESSEL D | 076 | KARIMUN | 4/15/2004 | OMAN CRUDE | 19,995.50 | SRIRACHA | 4/30/2004 | 0.861 | 23223.57724 |
| VESSEL D | 076 | BUNGA RAYA | 4/19/2004 | BUNGA KEKWA CRUDE | 62,262.58 | SRIRACHA | 4/30/2004 | 0.84 | 74122.11905 |
| | | | | | **82258.08** | | | | **97345.696** |
| VESSEL D | 077 | DUMAI | 5/3/2004 | DURI CRUDE | 29,116.64 | DAESAN | 5/18/2004 | 0.928 | 31375.68966 |
| VESSEL D | 077 | LABUAN | 5/8/2004 | LABUAN CRUDE | 57,654.13 | DAESAN | 5/18/2004 | 0.862 | 66862.48933 |
| | | | | | **86770.767** | | | | **98238.179** |

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|---|---|---|---|---|---|---|---|---|---|
| VESSEL D | 078 | KERTEH | 5/29/2004 | TAPIS BLEND CRUDE | 73,008.29 | BOTANY BAY | 6/14/2004 | 0.798 | 91489.08145 |
| | | | | | **73008.287** | | | | **91489.081** |
| VESSEL D | 079 | DAMPIER | 6/27/2004 | NWS CONDENSATE | 75,717.71 | SINGAPORE | 7/4/2004 | 0.738 | 102598.523 |
| | | | | | **75717.71** | | | | **102598.52** |
| VESSEL D | 080 | DUMAI | 7/11/2004 | SUMATRAN LIGHT CRUDE | 54,006.41 | OITA | 7/27/2004 | 0.852 | 63387.80516 |
| VESSEL D | 080 | SENIPAH | 7/17/2004 | SENIPAH CONDENSATE | 28,080.00 | MIZUSHIMA | 7/29/2004 | 0.769 | 36514.95449 |
| | | | | | **82086.41** | | | | **99902.76** |
| VESSEL E | 077 | LOS ANGELES | 2/5/2004 | FUEL OIL | 27,592.18 | SINGAPORE | 3/16/2004 | 0.966 | 28563.33333 |
| VESSEL E | 077 | LOS ANGELES | 2/5/2004 | LCO | 6,365.10 | SINGAPORE | 3/17/2004 | 0.913 | 6971.630887 |
| VESSEL E | 077 | LOS ANGELES | 2/5/2004 | DECANT OIL | 35,626.86 | SINGAPORE | 3/16/2004 | 0.975 | 36540.36923 |
| VESSEL E | 077 | ANACORTES | 2/12/2004 | HCGO | 11,723.44 | SINGAPORE | 3/18/2004 | 0.946 | 12392.64271 |
| | | | | | **81307.579** | | | | **84467.976** |
| VESSEL E | 078 | KARIMUN | 3/30/2004 | HSFO 180CST | 79,187.35 | HUANGPU | 4/9/2004 | 0.983 | 80556.81689 |

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|---|---|---|---|---|---|---|---|---|---|
| | | | | | **79187.351** | | | | **80556.817** |
| VESSEL E | 080 | KAKAP | 5/11/2004 | KERAPU CRUDE | 19,495.69 | MELBOURNE | 6/2/2004 | 0.795 | 24522.8805 |
| VESSEL E | 080 | SENIPAH | 5/17/2004 | SENIPAH CONDENSATE | 48,753.80 | MELBOURNE | 6/2/2004 | 0.769 | 63398.95969 |
| | | | | | **68249.49** | | | | **87921.84** |
| VESSEL E | 081 | DAMPIER | 6/22/2004 | COSSACK CRUDE | 81,832.03 | BRISBANE | 7/6/2004 | 0.79 | 103584.8481 |
| | | | | | **81832.03** | | | | **103584.85** |
| VESSEL E | 082 | KUMUL | 7/13/2004 | KUTUBU CRUDE | 72,094.00 | PORT MORESBY | 7/15/2004 | 0.804 | 89722.63887 |
| | | | | | **72094** | | | | **89722.639** |
| VESSEL F | 106 | LONG BEACH | 2/22/2004 | LIGHT CYCLE OIL | 31,659.82 | SINGAPORE | 3/28/2004 | 0.913 | 34676.69222 |
| VESSEL F | 106 | LONG BEACH | 2/23/2004 | DECANT OIL | 13,564.72 | SINGAPORE | 3/28/2004 | 0.975 | 13912.52923 |
| VESSEL F | 106 | SAN FRANCISCO | 2/25/2004 | CUTTER STOCK | 9,903.58 | SINGAPORE | 4/1/2004 | 0.975 | 10157.51692 |
| VESSEL F | 106 | SAN FRANCISCO | 2/25/2004 | HSFO | 34,719.47 | SINGAPORE | 4/1/2004 | 0.99 | 35070.17475 |
| | | | | | **89847.588** | | | | **93816.913** |

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|---|---|---|---|---|---|---|---|---|---|
| VESSEL F | 107 | FUJAIRAH | 4/12/2004 | HSFO 180CST | 85,543.08 | HUANGPU | 5/7/2004 | 0.983 | 87022.46287 |
| | | | | | **85543.081** | | | | **87022.463** |
| VESSEL F | 108 | DUMAI | 5/18/2004 | SUMATRAN LIGHT CRUDE | 78,939.81 | MIZUSHIMA | 5/29/2004 | 0.852 | 92652.35915 |
| | | | | | **78939.81** | | | | **92652.359** |
| VESSEL F | 109 | BINTULU | 6/8/2004 | BINTULU CRUDE | 41,899.63 | DAESAN | 6/17/2004 | 0.842 | 49762.03207 |
| VESSEL F | 109 | LABUAN | 6/10/2004 | LABUAN CRUDE | 40,369.07 | DAESAN | 6/17/2004 | 0.862 | 46816.71293 |
| | | | | | **82268.704** | | | | **96578.745** |
| VESSEL F | 110 | VUNGTAU | 6/26/2004 | BACH HO CRUDE | 39,506.02 | GEELONG | 7/25/2004 | 0.824 | 47944.19417 |
| VESSEL F | 110 | SERIA | 6/29/2004 | CHAMPION CRUDE | 15,781.00 | GEELONG | 7/28/2004 | 0.883 | 17872.02718 |
| VESSEL F | 110 | SERIA | 6/29/2004 | SERIA LIGHT EXPORT BLEND | 21,440.00 | GEELONG | 7/25/2004 | 0.843 | 25432.97746 |
| | | | | | **76727.016** | | | | **91249.199** |
| VESSEL G | 129 | VUNGTAU | 1/17/2004 | BACH HO CRUDE | 46,742.57 | MELBOURNE | 2/4/2004 | 0.824 | 56726.4199 |
| VESSEL G | 129 | RANG DONG | 1/18/2004 | RANG DONG CRUDE | 26,834.53 | MELBOURNE | 2/4/2004 | 0.826 | 32487.31961 |

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|---|---|---|---|---|---|---|---|---|---|
| | | | | | **73577.096** | | | | **89213.74** |
| VESSEL G | 130 | COSSACK PIONEER | 2/17/2004 | COSSACK CRUDE | 77,545.46 | NAKAGUSUKU | 2/28/2004 | 0.79 | 98158.81013 |
| | | | | | **77545.46** | | | | **98158.81** |
| VESSEL G | 131 | VUNGTAU | 3/13/2004 | BACH HO CRUDE | 76,303.31 | SINGAPORE | 3/17/2004 | 0.824 | 92601.10437 |
| | | | | | **76303.31** | | | | **92601.104** |
| VESSEL G | 132 | DAMPIER | 4/4/2004 | NWS CONDENSATE | 76,907.83 | ULSAN | 4/17/2004 | 0.738 | 104211.1518 |
| | | | | | **76907.83** | | | | **104211.15** |
| VESSEL G | 133 | SENIPAH | 4/28/2004 | SENIPAH CONDENSATE | 30,141.41 | KWINANA | 5/27/2004 | 0.769 | 39195.59168 |
| VESSEL G | 133 | BALIKPAPAN | 4/28/2004 | LSWR | 27,999.90 | OITA | 5/7/2004 | 0.904 | 30973.34071 |
| | | | | | **58141.31** | | | | **70168.932** |
| VESSEL G | 134 | DULANG | 5/18/2004 | DULANG CRUDE | 38,114.10 | KWINANA | 5/27/2004 | 0.763 | 49952.95282 |
| VESSEL G | 134 | GRIFFIN | 5/24/2004 | GRIFFIN CRUDE | 37,395.31 | KWINANA | 5/27/2004 | 0.763 | 49010.89122 |
| | | | | | **75509.413** | | | | **98963.844** |

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|---|---|---|---|---|---|---|---|---|---|
| VESSEL G | 135 | DAMPIER | 6/1/2004 | NWS CONDENSATE | 75,714.07 | YOSU | 6/14/2004 | 0.738 | 102593.5908 |
| | | | | | **75714.07** | | | | **102593.59** |
| VESSEL G | 136 | SERIA | 6/22/2004 | CHAMPION CRUDE | 84,198.00 | WHANGAREI | 7/7/2004 | 0.883 | 95354.47339 |
| | | | | | **84198** | | | | **95354.473** |
| VESSEL G | 137 | BAYU UNDAN | 7/30/2004 | BAYU UNDAN CONDESATE | 77,657.13 | SINGAPORE | 8/7/2004 | 0.727 | 106818.6039 |
| | | | | | **77657.125** | | | | **106818.6** |
| VESSEL H | 122 | SERIA | 3/7/2004 | SERIA LIGHT EXPORT BLEND | 84,051.00 | SRIRACHA | 3/12/2004 | 0.843 | 99704.62633 |
| | | | | | **84051** | | | | **99704.626** |
| VESSEL H | 123 | DUMAI | 3/17/2004 | SUMATRAN LIGHT CRUDE | 80,133.72 | SHIMOTSU | 3/28/2004 | 0.852 | 94053.66197 |
| | | | | | **80133.72** | | | | **94053.662** |
| VESSEL H | 124 | SERIA | 4/5/2004 | SLEB CRUDE | 42,234.00 | SRIRACHA | 4/10/2004 | 0.883 | 47830.12458 |
| VESSEL H | 124 | SERIA | 4/6/2004 | CHAMPION EXPORT CRUDE | 48,985.00 | SRIRACHA | 4/10/2004 | 0.883 | 55475.65119 |
| | | | | | **91219** | | | | **103305.78** |

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|---|---|---|---|---|---|---|---|---|---|
| VESSEL H | 125 | JEBEL DHANNA | 5/4/2004 | MURBAN CRUDE | 82,520.00 | MOMBASA | 5/14/2004 | 0.826 | 99903.1477 |
| | | | | | **82520** | | | | **99903.148** |
| VESSEL H | 126 | DURBAN | 5/21/2004 | FUEL OIL 180CST | 34,972.53 | SINGAPORE | 6/25/2004 | 0.966 | 36203.4472 |
| VESSEL H | 126 | DURBAN | 5/22/2004 | CLARIFIED OIL | 10,057.37 | SINGAPORE | 6/25/2004 | 0.966 | 10411.35611 |
| VESSEL H | 126 | SINGAPORE | 5/31/2004 | HSFO 180CST | 42,605.68 | SINGAPORE | 6/24/2004 | 0.966 | 44111.17899 |
| | | | | | **87635.578** | | | | **90725.982** |
| VESSEL I | 100 | SERIA | 1/18/2004 | CHAMPION CRUDE | 51,215.00 | BRISBANE | 2/10/2004 | 0.883 | 58001.1325 |
| VESSEL I | 100 | BUNGA KEKWA | 1/24/2004 | BUNGA KEKWA CRUDE | 40,254.00 | BRISBANE | 2/10/2004 | 0.84 | 47921.42857 |
| | | | | | **91469** | | | | **105922.56** |
| VESSEL I | 101 | DAMPIER | 2/25/2004 | NWS CONDENSATE | 76,068.92 | ULSAN | 3/8/2004 | 0.738 | 103074.4173 |
| | | | | | **76068.92** | | | | **103074.42** |
| VESSEL I | 103 | KARIMUN | 3/25/2004 | KUWAIT EXPORT CRUDE | 41,640.92 | SRIRACHA | 4/8/2004 | 0.871 | 47820.84452 |
| VESSEL I | 103 | KARIMUN | 3/25/2004 | OMAN CRUDE | 39,106.82 | SRIRACHA | 4/8/2004 | 0.861 | 45420.23229 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **80747.74** | | | | **93241.077** |
| VESSEL I | 105 | SERIA | 5/16/2004 | SERIA LIGHT EXPORT BLEND | 41,712.00 | BRISBANE | 6/6/2004 | 0.843 | 49480.42705 |
| VESSEL I | 105 | BENCHAMAS | 5/20/2004 | BENCHAMAS CRUDE | 44,292.42 | BRISBANE | 6/6/2004 | 0.814 | 54413.29238 |
| | | | | | **86004.42** | | | | **103893.72** |
| VESSEL I | 106 | DUMAI | 6/27/2004 | SUMATRAN LIGHT CRUDE | 81,649.89 | SHIMOTSU | 7/10/2004 | 0.852 | 95833.20423 |
| | | | | | **81649.89** | | | | **95833.204** |
| VESSEL I | 107 | DUMAI | 7/21/2004 | DURI CRUDE | 29,673.87 | YOSU | 8/12/2004 | 0.928 | 31976.15302 |
| VESSEL I | 107 | BINTULU | 7/24/2004 | BINTULU CRUDE | 34,808.98 | YOSU | 8/12/2004 | 0.842 | 41340.83373 |
| VESSEL I | 107 | SENIPAH | 7/30/2004 | SENIPAH CONDENSATE | 23,797.40 | YOSU | 8/12/2004 | 0.769 | 30945.90377 |
| | | | | | **88280.252** | | | | **104262.89** |

Source: Teekay Marine Services, (2006), *Cargoes Transported by the TK fleet in the Pacific Basin*, Personal Contact.

# APPENDIX 16 INVESTMENT ANALYSIS

## M.T. PRINCESS - NO CONVERSION

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capital Inv. | 0 | $ | Duration | 0 | days | Downtime | 0 | $ |

| | |
|---|---|
| Interest | 8% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Charter /day | 25,000 | until 2012* | Opex /day | 5000 | $/day | Operation | 300 | days |
| | 17,000 | until 2015 | *(Vessel is Excluded from Chinese ports after 2012) | | | | | |

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 | 5,100,000 | 5,100,000 | 5,100,000 | 0 | 0 |
| Opex | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | 0 | 0 |
| DD | -2,000,000 | | | -1,500,000 | | -1,500,000 | | | | | |
| TOTAL | 4,000,000 | 6,000,000 | 6,000,000 | 4,500,000 | 6,000,000 | 4,500,000 | 3,600,000 | 3,600,000 | 3,600,000 | 0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year Count (N) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Interest (i) | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% |
| P.V. | 3,703,703.7 | 5,144,032.9 | 4,762,993.4 | 3,307,634.3 | 4,083,499.2 | 2,835,763.3 | 2,100,565.4 | 1,944,968.0 | 1,800,896.3 |
| **Total P.V.** | **29,684,056.6** | | | | | | | | |

## M.T. PRINCESS - OPTION A

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capital Inv. | 5,150,000 | $ | Duration | 120 | days | Downtime | 3,000,000 | $ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Charter /day | 21,500 | | Opex /day | 5000 | $/day | Operation | 300 | days |
| Charter Adjust | 14% | | | | | | | |

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 |
| Opex | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 |
| Downtime | -3,000,000 | | | | | | | | | | |
| DD | -5,150,000 | | | -1,500,000 | | -1,500,000 | | | -1,500,000 | | |
| TOTAL | -3,200,000 | 4,950,000 | 4,950,000 | 3,450,000 | 4,950,000 | 3,450,000 | 4,950,000 | 4,950,000 | 3,450,000 | 4,950,000 | 4,950,000 |
| | | | | | | | | | | | |
| Year Count (N) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Interest (i) | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% |
| P.V. | -2,962,963.0 | 4,243,827.2 | 3,929,469.6 | 2,535,853.0 | 3,368,886.8 | 2,174,085.2 | 2,888,277.5 | 2,674,331.0 | 1,725,858.9 | 2,292,807.8 | 2,122,970.2 |
| **Total P.V.** | **24,993,404.1** | | | | | | | | | | |

## M.T. PRINCESS - OPTION B

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capital Inv. | 6,450,000 | $ | Duration | 150 | days | Downtime | 3,750,000 | $ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Charter /day | 23,750 | | Opex /day | 5000 | $/day | Operation | 300 | days |
| Charter Adjust | 5% | | | | | | | |

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 |
| Opex | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 |
| Downtime | -3,750,000 | | | | | | | | | | |
| DD | -6,450,000 | | | -1,500,000 | | -1,500,000 | | | -1,500,000 | | |
| TOTAL | -4,575,000 | 5,625,000 | 5,625,000 | 4,125,000 | 5,625,000 | 4,125,000 | 5,625,000 | 5,625,000 | 4,125,000 | 5,625,000 | 5,625,000 |
| | | | | | | | | | | | |
| Year Count (N) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Interest (i) | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% |
| P.V. | -4,236,111.1 | 4,822,530.9 | 4,465,306.4 | 3,031,998.1 | 3,828,280.5 | 2,599,449.7 | 3,282,133.5 | 3,039,012.5 | 2,063,527.0 | 2,605,463.4 | 2,412,466.1 |
| **Total P.V.** | **27,914,056.8** | | | | | | | | | | |

# M.T. CINDERELLA - NO CONVERSION LIFE EXTENSION

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Capital Inv. | 3,400,000 | $ | Duration | 75 | days | Downtime | 1,875,000 | $ | |
| Charter /day | 25,000 | until 2012* | Opex /day | 5000 | $/day | Operation | 300 | days | |
| | 17,000 | until 2015 | *(Vessel is Excluded from Chinese ports after 2012) | | | | | | |

| | |
|---|---|
| Interest | 8% |

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 | 5,100,000 | 5,100,000 | 5,100,000 | 0 | 0 |
| Opex | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | 0 | 0 |
| Downtime | -1,875,000 | | | | | | | | | | |
| DD | -3,400,000 | | | -1,500,000 | | -1,500,000 | | | | | |
| TOTAL | 725,000 | 6,000,000 | 6,000,000 | 4,500,000 | 6,000,000 | 4,500,000 | 3,600,000 | 3,600,000 | 3,600,000 | 0 | 0 |
| | | | | | | | | | | | |
| Year Count (N) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| Interest (i) | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | | |
| P.V. | 671,296.3 | 5,144,032.9 | 4,762,993.4 | 3,307,634.3 | 4,083,499.2 | 2,835,763.3 | 2,100,565.4 | 1,944,968.0 | 1,800,896.3 | | |
| **Total P.V.** | **26,651,649.2** | | | | | | | | | | |

## M.T. CINDERELLA – OPTION A

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capital Inv. | 6,950,000 | $ | Duration | 120 | days | Downtime | 3,000,000 | $ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Charter /day | 21,500 | | Opex /day | 5000 | $/day | Operation | 300 | days |
| Charter Adjust | 14% | | | | | | | |

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 | 6,450,000 |
| Opex | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 |
| Downtime | -3,000,000 | | | | | | | | | | |
| DD | -6,950,000 | | | -1,500,000 | | -1,500,000 | | | -1,500,000 | | |
| TOTAL | -5,000,000 | 4,950,000 | 4,950,000 | 3,450,000 | 4,950,000 | 3,450,000 | 4,950,000 | 4,950,000 | 3,450,000 | 4,950,000 | 4,950,000 |
| | | | | | | | | | | | |
| Year Count (N) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Interest (i) | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% |
| P.V. | -4,629,629.6 | 4,243,827.2 | 3,929,469.6 | 2,535,853.0 | 3,368,886.8 | 2,174,085.2 | 2,888,277.5 | 2,674,331.0 | 1,725,858.9 | 2,292,807.8 | 2,122,970.2 |
| **Total P.V.** | **23,326,737.4** | | | | | | | | | | |

## M.T. CINDERELLA – OPTION B

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capital Inv. | 8,050,000 | $ | Duration | 150 | days | Downtime | 3,750,000 | $ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Charter /day | 23,750 | | Opex /day | 5000 | $/day | Operation | 300 | days |
| Charter Adjust | 5% | | | | | | | |

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 | 7,125,000 |
| Opex | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 | -1,500,000 |
| Downtime | -3,750,000 | | | | | | | | | | |
| DD | -8,050,000 | | | -1,500,000 | | -1,500,000 | | | -1,500,000 | | |
| TOTAL | -6,175,000 | 5,625,000 | 5,625,000 | 4,125,000 | 5,625,000 | 4,125,000 | 5,625,000 | 5,625,000 | 4,125,000 | 5,625,000 | 5,625,000 |
| | | | | | | | | | | | |
| Year Count (N) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Interest (i) | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% |
| P.V. | -5,717,592.6 | 4,822,530.9 | 4,465,306.4 | 3,031,998.1 | 3,828,280.5 | 2,599,449.7 | 3,282,133.5 | 3,039,012.5 | 2,063,527.0 | 2,605,463.4 | 2,412,466.1 |
| **Total P.V.** | **26,432,575.4** | | | | | | | | | | |

Source: Harry Benford, (1991), *A Naval Architect's Guide to Practical Economics*, Department of Naval Architecture and Marine Engineering, University of Michigan.

ABBREVIATIONS AND GLOSSARY

| Abbreviation/ acronym | Name | Explanation |
|---|---|---|
| Aframax | | Tanker in the 75,000-120,000 dwt size range. Afra is average freight assessment. These ships are traditionally employed on a wide variety of short and medium- haul crude oil trades. |
| Al-Br | Aluminum-Bronze | Type of material used for cargo tank heating coils |
| Annual Survey | | Survey conducted by the classification society to asses the seaworthiness of a vessel annually |
| Ballast Water | | Seawater taken into a vessel's ballast tanks in order to submerge the vessel to proper trim and ensure stability |
| Ballast tank | | Tanks used for carrying the vessel ballast. They may be permanent, dedicated or cargo tanks |
| Ballasting | | The process of taking ballast water into the ballast tanks |
| Bareboat charter | | The hiring or leasing of a vessel from one company to another ( the charterer), which in turn provides crew, bunkers, stores etc. and pays all operating costs. |
| Bbls | Barrel | The standard unit of liquid volume in the petroleum industry. 1 Barrel = 42 US gallons = 0.1589 873 m3 |
| Benchmark Voyages | | A voyage used as standard for comparison for other voyages. |
| Blasting | | The preparation of a steel surface for painting by bombarding it with small particles. |
| CAP | Condition Assessment Program | Condition Assessment Program, conducted on owners request, which stipulates verification of the reported structural condition of the ship and that documentary and survey procedures have been properly carried out and completed |
| Car Carrier | | Vessel built for the transportation of cars |
| Cargo contamination | | The mixing of cargo with impurities that alter its cleanliness and chemical properties |
| Cargo Segregation | | The practice of keeping different batches/types of cargo separated in order to avoid contamination. |
| Cargo pump | | Pump used for the pumping cargo |
| CAS | Condition Assessment Scheme | Mandatory Condition Assessment Scheme which stipulate verification of the reported structural condition of the ship and that documentary and survey procedures have been properly carried out and completed |
| Charter Rates | | The agreed cost of hiring a vessel. |

| | | |
|---|---|---|
| Chemical Carrier CH | | Ship intended for carrying chemicals in bulk. |
| Classification Society | | The professional organizations that class and certify the seaworthiness of a vessel. |
| Commercial Pool | | A vessel sharing arrangement between owners that has as a purpose, the more efficient commercial management of their assets. |
| Container Vessel | | Ship intended for carrying containers |
| Crude Oil | | Unrefined oil directly from the reservoir |
| Crude Oil Carrier COC | | Vessel built for the transportation of crude oil |
| Crude Oil Washing | | A method of cleaning tanks using oil from the ships cargo. Normally used when a tanker is discharging. |
| Deadweight, dwt | Dead Weight Tonnage | The lifting or carrying capacity of a ship when fully loaded. The deadweight is the difference, in tonnes, between the displacement and the lightweight. It includes cargo, bunkers, water (potable, boiler, ballast), stores, passengers and crew |
| Decommission | | The decision and process of taking a ship out of service |
| Demolition | | The process of taking a ship apart including beaching |
| Dismantle | | The physical process of taking the ship apart, not including beaching |
| Docking Survey | | Survey conducted by the classification society to asses the seaworthiness of a vessel by examining its underwater parts. As the vessel is required to exit the water normally in a dock it is referred to as a docking survey. |
| Dry Cargo Vessel | | Vessel built to carry cargo of solid form |
| Dry dock | | A large dock from which water can be pumped out. Used for building or repairing ships below their water line. |
| Edge Preparation | | Edge Preparation is normally driven by the requirements of welding rather than painting. In the text and as part of the IMO Performance Standard for Protective Coating (PSPS) it used to describe preparation required for edges before the application of paint. |
| “FAIR” Coating Condition | | FAIR is a condition with local breakdown at edges of stiffeners and weld connections and/or light rusting of 20% or more of areas under consideration, but less than as defined for POOR condition. |
| Flag state | | Any state that allows ships to be registered under its laws. |
| Flue gas | | The mixture of gases forming the exhaust of the ship’s engines (Main and/or Auxiliaries) used as the basic constituent of inert gas to protect the cargo tanks. It is less combustible than air because much of the oxygen originally presented in the air drawn in for combustion has been combined with carbon and hydrogen to release heat energy. |

| | | |
|---|---|---|
| FPSO | Floating Production Storage and Offloading Vessel | |
| F.O.T | Fuel Oil Tank | Tank for the storage of fuel oil. |
| Free Surface Moments | | Moments caused by the free movement of a liquids surface in tanks. |
| Gas free | Gas free (for hot work) | An atmospheric condition in a tank, when it is free from any concentration of inflammable, noxious or toxic gases and vapors. |
| Gas Free Certificate | | A certificate issued by a chemist after sampling the air in the tankers cargo tanks. |
| "GOOD" coating condition | | GOOD is a condition with only minor spot rusting. |
| GT | Gross Tonnage | The internal capacity of a vessel. Under the terms of the 1969 Tonnage Convention, $GT=K_1*V$ where V is the total volume of all enclosed spaces in the ship in cubic meters and $K_1 = 0.2+0.02*\log_{10}(V)$ |
| Heating coils | | Coils located at the bottom of cargo tanks that steam passes through to heat cargo. |
| Heavy Lift Ship | | Vessel specifically designed to carry heavy or oversized cargoes. |
| IACS | International Association of Classification Societies | Classification Societies Members of IACS: ABS, BV, CCS, DNV, GL, IRS, KR, LR, NK, RINA, RS |
| IMO | International Maritime Organisation | The United Nations' agency responsible for improving maritime safety and preventing pollution form ships |
| In water survey | | Can be accepted by the classification society as an alternative to docking. Examining the vessels underwater parts by divers. |
| IG | Inert Gas | A gas used by marine tank vessels to displace air in cargo tanks to reduce oxygen to 8% or less by volume and thus reduce the possibility of fire or explosion. |
| IGG | Inert Gas Generator | A generator of inert gas. |
| Inerting | | A procedure used to reduce the oxygen content of a vessels cargo spaces by the usage of inert gas. |
| Intertanko | International association of | |

| | | |
|---|---|---|
| | independent tank owners. | |
| Lightship | | Weight of the vessels as built |
| Liquid carrier | | Vessel designed to carry cargoes of liquid form |
| LRII | Long Range II | Aframax size vessel built as long-haul product tankers, with epoxy coated tanks. |
| MARPOL | | International convention for the prevention of pollution from ships. |
| Nitrogen blanketing | | The process and practice of covering the surface of a stored commodity in a tank, with nitrogen gas keeping it in an inerted state. This method of inerting is used normally on small product/ chemical vessels. |
| OCIMF | Oil Companies International Marine Forum. | Organization of oil companies that own and operate ships. |
| Oil Majors | | Oil and gas companies involved in all stages of the oil industry, exploration, production, refining, trading, marketing and sometimes transportation. |
| Oil Products | | Useful materials derived from crude oil as it is processed in oil refineries. |
| OPA 90 | Oil Pollution Act of 1990 | US EPA Oil Pollution Act of 1990 on preventing of and responding to catastrophic oil spills |
| OPEC | Organization of Petroleum Exporting Countries | OPEC Current Members; Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, Venezuela. |
| Panamax | | A ship which is built within the dimensional limits (Length, Breadth and Draught) imposed by the locks of the Panama Canal. Such a ship typically has a deadweight tonnage in the range 55,000-70,000. |
| Parcels | | Term used to describe certain quantities of cargo. |
| Port state Control | | The process by which a state exercises control over vessels which call at its ports. In the United Kingdom (UK) the process of Port State Control is Carried out by the Maritime and Coastguard Agency (MCA). |
| PC | Product Carrier | Tanker that carries refined oil products. |
| Pump Room | | An enclosed area on a tank vessel which houses main and stripping cargo pump, ballast pumps, eductors and the associated piping and valves for their operation. |
| New Building | | The process of contracting and building a new vessel of agreed specifications in a shipyard. |
| Scantlings | | Scantlings are dimensions of structural members. |
| Scrapping | | “Neutral” word for the process of taking the ship apart without considering the procedures used. |
| Scrubber | | Unit used for the cleaning and cooling of the vessels flue gas used for inerting cargo tanks |

| | | |
|---|---|---|
| Semi Submersible | | A sea going, self propelled barge that rides at anchor, stands on partially submerged vertical legs on submerged pontoons, and serves as living quarters and a base of operations in offshore drilling. |
| Ship breaking | | The traditional process of taking a ship apart, including beaching. |
| Shipbreakers - Breakers | | Companies that demolish or cut up vessels which are obsolete or unfit for sea. The steel is used for scrap. |
| Sister Ships | | Ships built on the same design. |
| Slops | | A mixture of petroleum and water normally arising from tank washing. |
| Slop tank | | Tank where slops are kept. |
| Soot | | Black powdery form of carbon. |
| Special Survey | | The survey requirement of a classification society that usually takes place every five years. At the special survey vital pieces of equipment are opened up and inspected by the classification surveyor. |
| Specifications | | Technical document describing the scope and extent of work for the repair, conversion or building of a vessel. |
| Spot Charter | | Chartering on a single voyage or on a trip charter basis. |
| Stripe coat | | The application of an extra coat of paint by brush or by roller in areas that coating breakdown initiates from or are difficult to spray. |
| Submerged pumps | | Type of pump that works submerged in the pumping liquid. |
| Substantial limit | | Substantial is an extent of corrosion such that assessment of the corrosion pattern indicates a wastage in excess of 75% of the allowable margins, but within the acceptable limits. |
| Suezmax | | Tanker in the 120,000-200,000 dwt size range. The name was originally bestowed on the ship because in 1980 when a development project deepened the Suez canal depth to 16.1 m, the largest tankers being able to transit the canal laden were those between 140,000-150,000 dwt |
| Sulfuric Corrosion | | Corrosion caused by the presence of sulfur in various cargoes. |
| SUS | Steel Use Stainless | The term SUS is commonly used before the grade of the steel to indicate that the material is stainless i.e. SUS 304, SUS 316, SUS 430 etc. |
| Tank cleaning | | The process of cleaning a cargo tank from the remains of its previous cargo and preparing it for its next cargo. |
| Tonnage | | Tonnage, which may be Gross, Net, Deadweight or Displacement, is a measure of ship size; other measures of size which may be relevant could include Length or Volume. |
| Time Charter | | A “time charter” involves the use of the vessel, either for a number of months or years or for a trip between specific delivery and redelivery positions, known as a trip charter. The charterer pays all voyage-related costs. The owner of the vessel receives semi-monthly charter hire payments on a per-day basis and is |

| | | |
|---|---|---|
| | | responsible for the payment of all vessel operating expenses and capital costs of the vessel. |
| VLCC | Very Large Crude Carrier | Tanker in the 200,000-320,000 dwt size range. |
| Voyage Charter | | A "voyage charter" or "spot charter" involves the carriage of a specific amount of cargo on a load-port to discharge-port basis. The owner of the vessel receives one payment derived by multiplying the tons of cargo loaded on board times the agreed upon freight rate expressed on a per-ton basis. The owner is responsible for the payment of all expenses including voyage, operating and capital costs of the vessel. |

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