ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING AND TECHNOLOGY

ULTIMATE SIZE OF THE CONTAINERSHIP

M.Sc. THESIS

Nurullah EKIN

Department of Naval Architecture and Marine Egnineering

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

MEGA KONTEYNER GEMISI

YÜKSEK LİSANS TEZİ

Nurullah EKIN
(508091014)

Gemi İnsaatı ve Makineleri Mühendisliği Anabilim Dalı

Gemi İnsaatı Mühendisliği Programı

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EYLUL 2011

Nurullah Ekin, a **M.Sc.** student of ITU **Graduate School of Science Engineering and Technology** student ID **508091014**, successfully defended the **thesis** entitled "**ULTIMATE SIZE OF THE CONTAINERSHIP**", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor :	**Prof. Dr. Mustafa INSEL** İstanbul Technical University	....
Jury Members :	**Prof. Dr. Ömer GÖREN** Istanbul Technical University	....
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To my family,

FOREWORD

From the day I started working on this MSc Thesis, many people supported me and they provided invaluable advice, assistance and support to me. First and foremost, I would like to express my deepest gratitude to my supervisor Paul Stott who has been very patient in guiding me during the research period. His collaboration, support, constructive suggestions and his valuable experience of shipping marketing have assisted me in overcoming volatile time when composing a good piece of academic research seemed impossible to me. Also, I would like to thank Prof. dr. Mustafa Insel (Professor, Naval Architecture Programme at Istanbul Technical University) for his inspiration and kind encouragement, especially, I got really precious information about technical details of my study, during the modelling my research process.

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Last but not least, I would like to thank all the anonymous companies which participated in this research. Without their contribution, the invaluable contents of this thesis would never have materialized

December 2011 Nurullah EKIN

(Naval Architect)

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ABBREVIATIONS

ABS	: American Bureau of Shipping
BIMCO	: Baltic and International Maritime Conference
ECLAC	: Economic Commission of Latin America and Caribbean
EHP	: Effective Horse Power
IMF	: International Monetary Fund
IMO	:International Maritime Organization
ISO	:International Organization for Standardization
TEU	:Twenty Equivalent Unit

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ULTIMATE SIZE OF CONTAINERSHIP

SUMMARY

It is a well-known fact that volume of liner shipping marketing has been increasing and competition between shipping companies has started to be more aggressive. In the light of current market situations where huge orders of mega containerships are building up in order to get more profit, this thesis proposes as its principle objective and in depth analysis on the "ultimate size of containership" for liner shipping companies. To accomplish this aim, there are some obstacles which should be attempted for large vessel and after that the ship can sail between significant hub ports. This scenario base on ports and companies' future plans within next five years due to reach certain volume of containers.

The literature body is devoted to studies on the economies of scale with regards to ship operations. Besides, key factors of determining ultimate volume of container vessel is studied in literature review and world economy conditions and liner shipping marketing volume are explained as well. Besides, containership operational cost and supply-demand chain of liner shipping marketing are generated in order to reach better result of designing 7th generation containership.

The study focus of this thesis comprises a quantitative approach and support with a qualitative approach. In the first place, the qualitative approach is in-depth gathering information about liner shipping marketing and their existing conditions. In the second place, the quantitative approach will be mainly using a technical modelling-formula and result estimate cost to make requirements of ultimate size of containership clear.

According to result of my study, containerization has spread throughout the world and demand on liner shipping has been rising. To handle this, companies are working on volume of ships and they try to optimize them to get more benefit such as; just in time, less bunker cost, more capacity and speed. Vessel sizes have gradually increased to compete in the aggressive marketing conditions. In the light of foregoing, the ultimate vessel size is designed considering by existing limitations and obstacles. It can be served a few hub ports since ports conditions and regulations are limited. Moreover, 7th generation must sail between Asia (Singapore-Shanghai) to America (Los Angeles-Long Beach) because they allow the ship deploying boxes and it is more efficient way to provide advantages to companies.

The results and model will serve as a platform according to planning requirements as well as for terminal operators' future plans because the ship' load has some limitations to be handled. It is not only just finding the ultimate size of containership but also implementing cost efficiency for shipping marketing, thus permitting lower cost of transportation.

MEGA KONTEYNER GEMISI

ÖZET

Dünya genelinde işlem hacminin hızla artmasıyla birlikte konteynır taşımacılığı da hızla yükselişe geçmiştir. Deniz yolu taşımacılığı diğerlerine göre çok daha ucuz ve güvenilir olduğu için firmalar bu alanlara büyük yatırımlar yapmıştır. Bununla birlikte rekabet artmış ve lojistik şirketleri "farklılıklar" yaratmaya başlamıştır. Global finans sıkıntıların artmasından ve yakıt fiyatlarının sürekli dalgalanmasından dolayı yeni stratejiler artık kaçınılmaz olmuştur ve böylece gemi taşımacılığı artık yeniçağına girmiştir. Rekabet sisteminde ayakta kalabilmek ve büyümek için "konteyner taşımacılığı" geliştirilmiş olup yüksek kapasiteli konteynır gemileri üretilmiştir. Teknolojinin gelişmesi ile birlikte mega konteynır gemilerinin yapılması artık hayal dışı olmuş olup firmaların ayakta kalabilmesini sağlamıştır.

Büyük kapasiteli gemilerin çalışabilmesi için gereken teknik koşullar hızla iyileştirmiş olup "hub limanlar"ın sayısı hızla artmıştır. Deniz taşımacılığındaki en çok üzerinde durulan hususlardan bir tanesi doğru zamanlamadır bu yüzden konteyner limanlarındaki kreyn sayıları artırılmıştır. Mevcut limanlara devlet tarafından destekler artmış olup daha modern ekipmanlar alınmaya başlanmıştır ve böylece daha kısa zamanda daha fazla konteynır elleçlenmesi yapılabilmektedir. Yüklerin indirilip-boşaltılması esnasında yardımcı ekipmanların önemi anlaşılmış olup bu işlemlerin daha hızlı yapılabilmesi içinde barkot veya gps gibi sistemler konteynırlara entegre olmuştur.

Her ne kadar en büyük kapasite ve boyutlarda konteyner gemisi inşa etme arzumuz olsa da ekonomik koşulların buna hazır olması çok önemlidir. Bu çalışmanın ilk kısımları "liner taşımacılık" ile ilgili olup son on yıl içerisinde olan değişikler üzerinde durulmuştur ve gelecek yilların nasil bir talep getireceğini ve ne gibi ihtiyaçlar doğuracağını da bazı IMF verileri ile sentezlenmiştir.

Bu çalışmanın uygulanabilirliği açısından bazı "sınırlamalar" üzerinde durulmuştur ve inşa edilebilecek uygun bir gemi profili tasarlanmıştır. Göz önünde bulundurulan kısıtlamalar başlıca ekonomik koşullar olmak üzere, liman derinlikleri, kreynlerin kapasiteleri, manevra alanı ve kabiliyeti, işlem hacmi ve ekonomik şartlar olmak üzere teknik anlamda inşa olanakları da çalışmanın bir parçası olmuştur.

Bundan 50 yıl önce uzmanlar dâhil hiç kimse devasa gemilerin yapılabileceğini hayal bile edemiyordu fakat kimyasal tankerlerin hızla gelişmesi bu sınırları zorlamıştır ve 25 metre draft sınırları geçilmiştir. Konteyner gemileri için her geçen gün yeni çalışmalar yapılmakla birlikte sınırlar 400 metre üzerinde olmaya başlamıştır.

Bu çalışmaları yaparken en büyük engellerden bir tanesi gereken makine gücünün çok fazla olması ve bunun istenilen hacimlerde olmaması ciddi sorun teşkil etmektedir. Bu doğrultuda gelişen teknoloji ile birlikte makine-form uyumu daha

büyük önem kazanmıştır ve yeni sevk sistemlerinin kullanılması artık kaçınılmaz olmuştur.

Denizcilik taşımacılığında navlun fiyatları günlük bazda dâhil değişmektedir ve gelişen her olumlu-olumsuz süreçler fiyatları doğrudan etkilemektedir. Bunun yanı sıra, yakıt harcamalarının denizcilik taşımacılığında en büyük payı aldığı düşünülürse bu doğrultuda yapılan çalışmaların şirketler için ne kadar hayati derecece önemli olduğunu ortaya koymaktadır. Şirketler sürekli değişen bu parametrelerle mücadele etmek için farklı çözümler aramaktadır. Bu doğrultuda atılacak en büyük adımların başında gemilerin tam yüklü ve sürekli çalışması gelmektedir. Konteyner gemilerin belirli limanlar arasında sürekli çalışması ve ondan sonraki yük akışı için ise de küçük hacimli konteyner gemilerinin çalışıtırlması bir çözüm olarak ortaya çıkmıştır.

Yukarıda nedenlerin yeterli olmamasından ötürü, ortaya konan en verimli çözüm yolunun daha büyük hacimde ve daha az yakıt tüketimde olan yeni nesil gemilerin inşa edilmesi uzmanların ortak kararı olmuştur. Konteynır taşımacılığında büyük pay sahibi şirketler gemi siparişlerinin sayısını artırmış olup sürekli değişen ekonomik şartlarla mücadele için yeni çözüm yöntemi olarak ortaya çıkmıştır. Yeni nesil olarak adlandırılan 18,000 TEU hacimli on adet konteyer gemilerinin uzak doğuya sipariş edilmesi piyasada yeni bir akımın çıkacağına aşikârdır.

Bu çalışmaya başlamadan önce inşa edilebilecek en büyük konteyner gemisi için engel konumundaki bazı koşulları çalışmanın üçüncü ve dördüncü bölümlerinde sundum. Bu engeller başlıca; mevcut liman koşulları, rıhtım derinliği, ulaşım koşulları, arz-talep dengesi, navlun ve petrol fiyatları yer almaktadır. Bu bahsi geçen koşulların olumlu olması durumunda da bazı teknik anlamdaki zorlukların dikkatlice incelenmesi ortaya konacak çalışmayı daha kapsamlı hale getirmiştir.

Tüm bu engel teşkil eden ve geminin teknik anlamda şekillenmesini sağlayan faktörler incelendikten sonra beşinci bölümde mega geminin Rhino programında formu istenilen boyutlarda tasarlanmıştır ve sonradan bu form Maxsurf Pro programına transfer edilerek hız-direnç ve hız-güç eğrileri elde edilmiştir. Elde edilen bu değerler matematiksel yöntemlerle hesaplanan güç değeri ile karşılaştırılmış olup hata payı 5% civarında olduğu görülmüştür. Teknik koşulların yeterli düzeyde olmaması sebebiyle bu tasarlanan geminin daha verimli kullanılabilmesi için belirli limanlar arasında, yüksek teknolojili, çalıştırılmasının daha verimli olduğu öne çıkmıştır.

Tüm koşullar göz önüne alındığı takdirde inşa edilebilecek en büyük geminin boyu 450 metre, genişliği 62 metre, draftı 16,7 metre ve toplamda 21,000 TEU kapasiteli olabileceği görülmüştür. Bu kapasitede ki geminin yüklerinin hızlı bir şekilde elleçlenmesi için yaklaşık olarak 6 adet gantry kreynin aynı anda çalışması gerekmetedir ve bu sayıda ekipmana sahip olan modern limanların sayısı sınırılıdır. Tüm bunlar dikkate alındığında, mega geminin Singapur- Los Angeles veya Long Beach- Rotterdam limanları arasında çalışması şirketler için daha fazla kazançlı olduğu çalışmanın son kısımlarına doğru gösterilmektedir.

Yakıt tüketim maliyetini aşağıya çekebilmek için yeni nesil gemi motoru tercih edilmiş olup iki makine kullanılmıştır. Gemi direncinin gemi hızının küpü ile orantılı olduğu göz önünde bulundurulmuştur ve gemi dizayn hızının 24 knot olmasına direnç-hız eğrisi incelendikten sonra karar verilmiştir. Hali hazırda en büyük konteynır gemisi olan Emma Maersk ile ekonomik anlamda detaylı karşılaştırmalar altıncı bölümde yapılmıştır ve "mega konteynır gemisinin" 13% gibi bir oran fazlasıyla daha kazançlı olduğu ortaya çıkmıştır.

Gelişen ekonomik krizlerin ve soğuk savaşların petrol fiyatlarına etkisi denizcilik şirketlerine ciddi zararlar vermiştir ve bununla mücadele etmenin en kolay yolu "mega gemiler" olduğu sonuç bölümünde sunulmuştur. Daha büyük sayıda yük taşıyabilecek gemiler özellikle, yakıt, mürettebat, liman masraflarını en aza indirerek navlun fiyatlar üzerinde de yeterli esnekliği şirketlere sağlamaktadır.

Yaptığım çalışmada yukarıda değinilen kriterler göz önünde bulundurularak "mega konteyner gemisi" tasarlanmıştır ve bunun bir çok ekonomik avantajı olduğu son bölümde gösterilmiştir. Mega gemi yeterince büyük ve teknik anlamda üst seviyede olan konteyner limanlar arası çalışabilir. Bu kapsamda bu geminin daha verimli kullanılması açısından "Transpacific" hatta (Singapur-Los Angeles) operasyonu çok daha verimli olduğu anlaşılmıştır.

1. INTRODUCTION

1.1 General Introduction

In an ever changing global scene, the maritime industry has had her challenges. With the World economy becoming more accessible due to the revolution of container shipping, container trade has been steadily increased during the last fifty years. It is a well-known fact that demanding on containerization has been rising and, it is carried out new circumstances which should be done by companies.

As Stopford (2008) pointed out that containerization is successful idea to reduce port time and, container service infrastructures have been developing by companies and ports. Improving fleet of container ships is a big challenge and it is required a few important things such as; container terminals performance, handling-equipment and the global trade volume-demand. Moreover, it is mentioned in his study for another point of liner operation principles and container services had extensively get new role by the end of the twentieth century. Besides, logistics companies focused on transport management and, they carried out new targets which might be potential for containerization.

Over the past four decades, container transportation has been studied by lots of scientists. Payer (2005) said that volume trade of the container has almost doubled and dimensions of containerships have increased steadily .However, to prepare for new generation of container ships ports and ship owners have noticed importance of planning and its procedure in advance to accommodate this growth.

Continued growth of global containerization has led to the deployment of larger cellular container vessels. Many industry forecasters suggest the next generation of mega-size container ships will be 18, 000 to 22, 000+TEU. These massive ships will serve only a limited number of deep water or off-shore transhipment hub ports (Ircha, 2001). Furthermore the penetration of containers is associated with upsizing of container vessel and Cullinane and Khanna (1999:193) pointed out “the latest generations of container ships make considerable demands on terminals and ports in the form of additional infrastructures, cranes, depth in ports, productivity, etc."

Recently, there has been growing interest in investigation optimum size of the container ships and, it has been found that there are so many steps which must be considered. Even if we would like to design largest vessel to be served, there are some limitations. According to those certain limitations I am going to suggest ultimate size of the container ships. Recent concerns about ultimate size of container ship have generated a considerable body of research

1.2 Objective and Scope of Study

Determining and pointing out an "ultimate" sized on liner shipping service route is critical and importance for shipping companies. One of the biggest problems for charter companies is expenditure of the ships and we should consider so many stakeholders involved which are affected in one way or another. Some of the milestones are liner shipping companies, ports, government agencies, banks, terminal infrastructure, inland ways, and ship brokers. When new types of bigger container ships were delivered to be served, a few big companies were affected negatively because they had to compete with different ways. Bigger ships have changed freight rates and ports time since companies have started to invest huge money to generate "ultimate" size. They have got so many benefits from bigger volume ships size such as; decreasing cost of the crew, less consumption of oil, and saving time.

As it is mentioned above, situation of world economy directly affect shipping industry, especially, between East-West routes. A few significant things are always demanded by shipping marketing and they want to supply at higher speed than normal service speed since more voyages can be completed within same period of time. Decision makers of such investments have planned that they have certain budget to invest shipbuilding industry to design new concept and the idea is corporate with new strategy for future expansion plans. Designing ultimate containership size is required to clarify certain limitations which are obstacles to handle container such as; operating systems, infrastructures, main engines- propeller, network systems, international rules and regulation, and the shipping routes.

Several studies have investigated that there should be hub ports, sufficiently enough marine technology and logistical systems for cargo handling. In the container trade, specialization meant ports were required to be invested for new ship-to-shore quayside gantry cranes, expanded land-side container storage yards, improved and automated container handling equipment, and on-dock rail transfer systems (Ircha, 2001). Today's trend of deploying ever-larger container ships continues to force ports to replace existing cargo-handling systems with longer out-reach post-Panamax gantry cranes and other equipment and, even greater cost, deepening access channels and water depth at berths(Pancanal, 2010).

Some attempts have been made to optimize container ship size and some of these studies have addressed to ultimate size. However, in the process of time, shipping industry conditions and technologies have been changed and new concepts will be designed in this study under the new circumstances. The main purpose of this dissertation is "what is likely to be ultimate size of container ship" for future plan and, this dissertation seeks to point out the possibilities and procedure for making better business decisions for shipping marketing.

1.3 Research Stages

As long as we have existing terminal conditions and its substructures, it is really hard to design "ultimate sized" ship. First of all, to remedy ports systems can be good start and then sweeping sea ground to increase depth. Afterwards, number of deploying equipment can be enhanced for feeder ships. Main process could be in different stages;

- Identifying research tools and necessity of shipping marketing
- Consideration of supply-demand chain for liner shipping
- Existing container vessels conditions and innovations
- Transpacific route and its capacity-inland ways for hub ports
- Determining internal and external critical factors to design new (7^{th}) generation of container ship

- Clarifying certain limitations which are handicap to deploy more containers such as; operating systems, infrastructures, main engines- propeller, network systems, international rules and regulation, and the marketing conditions
- Making a decision what features make ultimate container size more competitor and their service time
- Carrying out technical details such as; strength, hatch covers, main engine-propeller harmony, regulations and security (ABS Lloyd, 2010).
- Modelling new design ship which is more sensitive to environment
- Pointing out profit differences between existing ship and “ultimate” container size

1.4 Presentation of Study

The dissertation shall consist of six chapters. The First chapter provides the outline of the study, describing the benchmarks behind the research, the objectives and scope of study for innovation of shipping industry.

Evolution of containerships, container vessel sizes and general overview of the shipping marketing are mentioned in chapter two. In addition to this, types of shipping services, specification of liner shipping industry, transpacific route volume, and international rules-regulations are covered.

Chapter three light the way general review on the literature, especially, making differences profit rates to show the advantages of “ultimate” size for future. Based on the theoretical concepts reviewed and notable limitations, factors for determining 7th generation of container vessel, infrastructures requirements are also elaborated on and presented.

Chapter four covers effects on mega vessels performance. First of all, it is based on available data, articles and publications. It can be seen clearly from this chapter, economically comparisons relies on for different size of the ships. Moreover, requirements for new type of vessel, service period and port infrastructures also mention in this chapter.

Chapter five, which is one of the main stages to compose this study, tackles modeling ultimate size specifications, technical details, marketing conditions, factors of transporting service, and optimization according to some restrictions.

Finally, chapter six sum up the thesis with some important suggestion arising from the study. Recommendations are made for future studies on similar points and subject matter. In the nutshell, comparisons composed last part with summary part in terms of freight rate.

2. RESEARCH SETTING

2.1 Evolution of Containerships and Containerships Size

The first containership in the world was named *ideal X* it cast off from Berth 24 at the Marsh Street in Port Newark, New Jersey, and set a course for Houston, Texas on April in 1956. As pointed out in the article, containerization has gone through two phases during its life. In the first place, seaports got started to deal with four distinct generations ship size till the Panamax limit carried out with 13 containers and wide of the deck extended 32.2 meters. In the second place, shipping marketing supply was changed by World's commerce demand and second phase emerged which participated organizational and logistical reorientation for new system. Afterwards, new generation ships were built up and their size was beyond the Panamax limit (Ircha, 2001). Furthermore, global industry has brought some challenges and the idea of designing larger containerships came out. When adaptation period for containerization was finished by port authority, shippers may surprise at the wonders of "just in time" chains of international delivery that this situation accelerate shipping marketing efficiency (Cudahy, 2004).

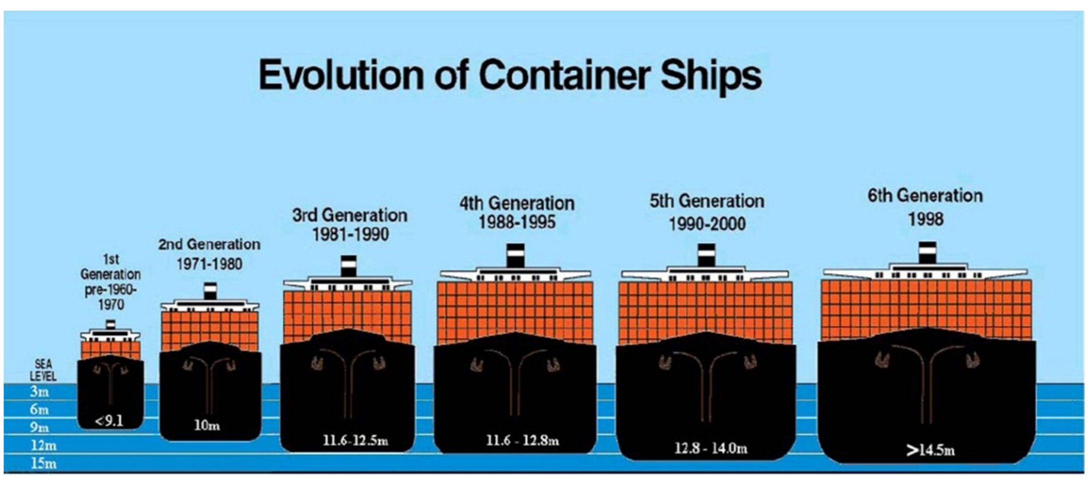


Figure 2.1 Evolutions of container ships (Global Security, 2011)

According to World's trade, dimensions of ships have been changed and terminals have tried to extend their ports. One of the main problems for larger ships is port draft and they focus on dredging their channels and area to deploy more containers. As it can be seen above figure, containerships can be break into different generations which based on their capacity in terms of TEUs.

Even though first generation had less than 1.000 TEU capacities, this elementary evolution gave inspiration to shipping industry nearly 1960. One of the typical first generation containership was "America" and she was 25meter wide, 175 meter long, and 9.5 meter draft with 15.440 dwt. She had a capacity of 786 containers, 228TEUs stacked with 2 high and 8 across deck and rest of them inside the hatch with 6 high and 7 across (Kee, 2006).

The second generation containerships had a 10m draft with ranging capacity from 1.000TEU to 3.000TEU. These types of ships were served advanced countries since 1966. In additon to this, length of the ships was between 250-250m and maximum number of rows was 12.

The third generation containerships had slot capacity between 3000TEU and 4000TEU on board. one example for third generation was "Frankfurt" which had 271m long, 13m draft and its capacity was 3045TEUs. Ther was no differences about breadth but they were served within developing countries such as; South East Asia, Middle East, South America.

The fourth generation containership capacity ranged from 400TEUs to 6000TEUs. They begun to be served long between international routes since 1984, especially, deviation from ISO standart started to be used. "Truman" was one of the first vessel for this type which which had 275m long , 12.5m draft with 39.4m (Kee, 2006)

After new marketing conditions determined new types of containerships which is called fifth generation. During this period , a few big liner shipping companies played role and they built up ships which has over 6000TEUs. When World's commerce based on shipping, lots of new ports started to construct and their conditioan recovered for new types of containerships.

New era begun with the six generation containerships which has a capacity more than 8000TEUS. " Emma Maersk" is one of the best example for this type and she has 397meters, width of 56meters, depth of 30 meters. She is able to carry 11000

TEU, 22 rows of container on deck and stacking up to 8 high give her to load 3000 more containers (Kee, 2006).

To sum up, containership capacity has increased by tenfold during the fifty years and there are so many improvements which give the possibilites to constuct larger ship. It has been driven by demands of shippers to increase capacity and minimizing transortation cost.

2.2 Review of the Global Container Volumes

Container shipping is responsible for the movement of a wide range of goods from one place to another in a unitized form. Container shipping industry represents an important and increasingly significant role for global movement of goods. In the research of Alphaliner Company (2010), global container trade reached nearly 560 million TEU and number of containerships has been increased at the same time.

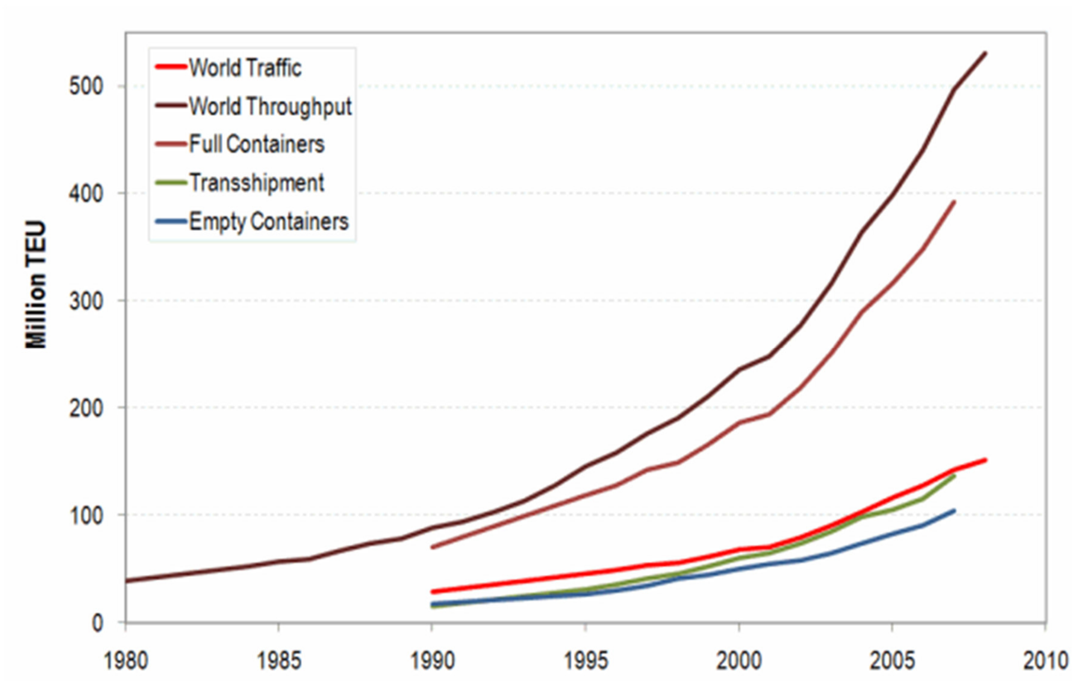


Figure 2.2 World container trade (Drewry Shipping, 2009)

Between 1990 and 2008, container traffic has raised from 28.7 million TEU to 152 million TEU with increase by 430 %. In the same period, container throughput changed from 88 million to 530 million TEU, an increase nearly tenfold, equivalent to an average annual compound growth of 10.5%. As a consequence, the ratio of container traffic over container throughput was approximately 3.5 in 2008, whereas this ratio placed at 3.0 in 1990. This main difference is carried out by the growth of international trade, adoption of containerization also made contribution to this situation.

Container trade volume directly depends on economic growth. Even if we have some estimation for volumes, economic crisis may come out and containerization can be affected. IMF projection supplies new estimates for shipping economy and their projections however extend through 2009 to 2015.

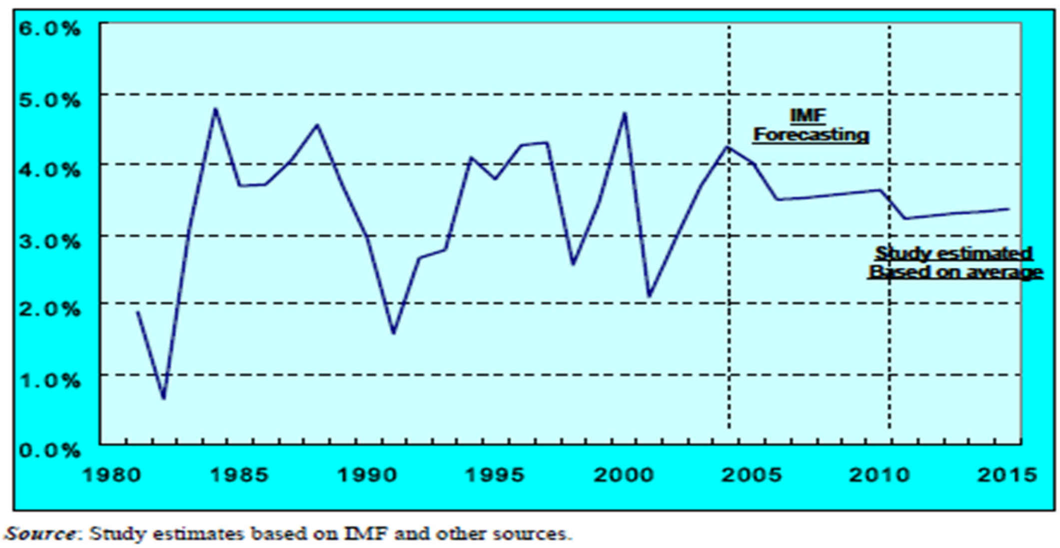


Figure 2.3 Economic growth and estimations (UNESCAP, 2007)

A recent forecast about world terminal container is throughout growth of nearly 600 million TEU in 2015. When container trade grows, the ship's size becomes longer and these types of ships are required container consolidation at designed hub ports (Ircha, 2001).

Table 2.1 Growths rate container trade (UNESCAP, 2007)

Year	Container Volumes(millionTEU)	Average growth rate over previous period
1990	28.7	7.8%
2000	68.7	9.1%
2010	138.9	7.3%
2015	177.6	5.0%

On the whole, below figure clearly indicates that container trade increase steadily, especially when ports has started to become more modernized and shipping size has been increased. This study brings some important challenges for shipping companies about designing ultimate size of containerships and building up new hub ports. If we look nearer for the last decades, as it is seen UNESCAP study, in every ten year container volumes almost doubled. To sum up, the one of the biggest reason for this rate of containerization trade is participating China to the World economy. Number of ships which works between Asia and America has been increased because so many good flows from China to the World.

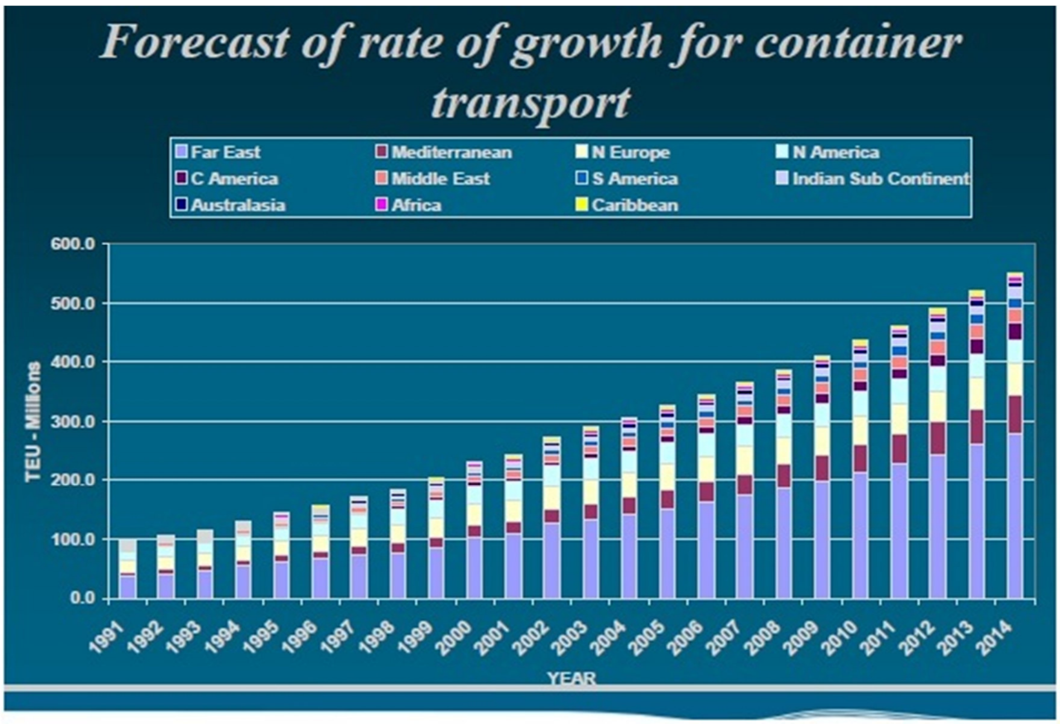


Figure 2.4 Forecast of rate of growth for container transport (UNESCAP, 2007)

Container traffic in other parts of Asia is expected to grow more rapidly than world average. This expectation comes from particularly in China, since there is continuing trend of last ten years. Moreover, solid growth is expected in South Asia where so many modern hub ports and larger containerships have already designed. Taken together, Asia's container trade volume get placed nearly over 55 percent and it is expected it will be approximately 64 percent within next five years. North America and Europe countries share almost same rate for container transport with 15 percent (UNESCAP, 2007). Consequently, as we can see above graphic, container transportation will increase almost every part of the World. The most important point is that busiest route is between China and America. According to this information, ultimate size of containership can be designed for transpacific route with modern system.

2.3 Types of Shipping Service

Sea trade can break into three groups such as; bulk cargo, specialized and general cargo they are also can be extended according to their function within them (Stopford, 2008).

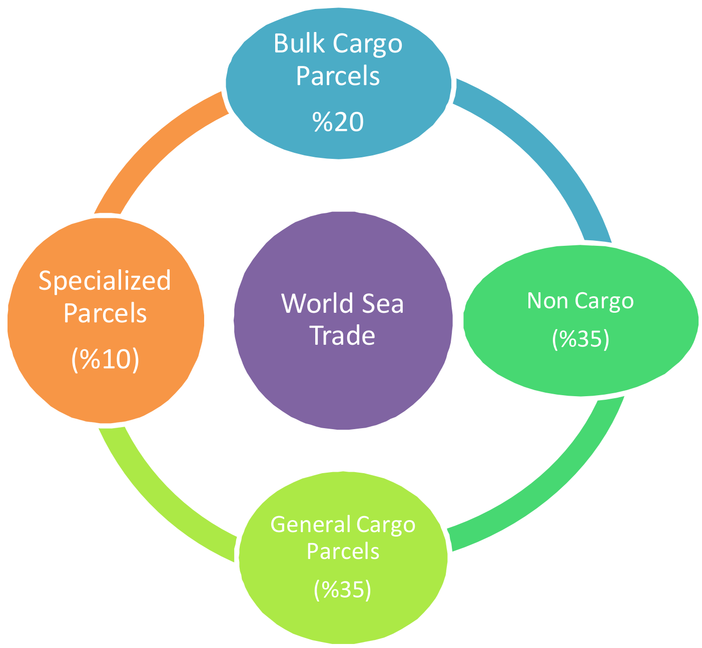


Figure 2.5 Sea transport systems (Stopford, 2008)

Bulk shipping industry: One of the main differences between liner and bulk shipping is method of competition. Bulk marketing generally competes on price while liner shipping industry works for in term of transit time and number of service (Marcus, 1987). Bulk vessel owner have more option for contract so that they can charter their ships different ways and period. Even though bulk shipping and liner shipping are quite different, some respects on making money are same. As Martin Stopford pointed out, bulk vessels generally complete nearly six services with a single cargo per year. Little overhead is required to serve the ships since service levels are rarely. Bulk shipping marketing requires more employees for each ship at the sea and it cost money for company.

Liner shipping industry: Liner operation can be into a few distinct departments but it is specialized by a fix schedule whole year services to certain ports which are situated different countries. Even if she is not full totally, these types of ships always sail around the world and their service time also depends on railway and inland transport system. The era of global logistic may supply new opportunities for container and Ro-Ro transportation such as ports operation time and inland ways through the ports (Branch, 2008). Liner shipping firms can face two certain choices when they want to make maximum profit. Firstly, they can make a choice of any market to serve their ship and this way can decrease their risk. Secondly, they may cooperate with other carriers according to marketing behaviour they choose suitable one (Pozdnakova, 2008). One of the best examples for liner shipping company is Maersk Line because they put the right position each elements such as; space management, hinterland, intermodal transport, management information systems, port equipment and terminal operations. As a result of organic growth, The Maersk Line expands its volume and reached over 500 vessels with more than 1,400,000 TEUs. It represents that Maersk share nearly 17 percent of liner shipping marketing according to Maersk press in 2007.

Specialized shipping service: This type of shipping contains a few particular elements such as; motor cars, forest products, refrigerated, chemicals and liquefied gas. These trade situated somewhere between bulk and liner marketing. The companies which run for specialized shipping offer higher service quality than bulk companies. Principal distinguishing feature of specialized trades is that they use specific ship designed which allow carrying different type of cargo for particular target costumer. Although it looks risky about features of ships, cargo handling and storage goods but it is worth to invest money for specific cargo (Stopford, 2008). The important point is that "specialization" is not only about the ship specification but also adapting the shipping operation to the needs of target costumer. To demand this type of ships may require more money than others because specific equipment is necessary to handle goods. Finally, Specialist shipping companies are easier to recognize than the others because they have certain specifications.

2.4 Trend of Liner Shipping Service in the World

Opening Suez Canal in 1869 and creating steamships gave opportunities for liners which allow the new commercial systems. After four years from opening Suez Canal, freight market boom and companies ships set up to be served Far East route. Network of liner services increased rapidly and it brought new technological and complex structures. Designing and qualifying “tweendeckers” ships which used by tramp opened new era and it changed some routes of service because of the chartering. The old systems refined nearly end of the twentieth century and it increased productivity and trade volume. At the same time, liner owners built more sophisticated cargo liners and they started to divide the ships for different goods (Stopford, 2008).

The trend of liner shipping in the world depends on developments and movements World economy and the liner industry has broken into a new era which give the possibilities for containerships and logistic providers (Rogan, 2006). As it is shown the report of ECLAC, liner shipping marketing means larger shipping companies and they hold big part of the industry. There are two factors which can affect directly to this industry, ports and World finance situation. In addition, getting overcapacity, export and import rate and fluctuations of freight rates can damage companies profit even it is generally positive. As *Gust et al*. point out some interesting and remarkable improvements have been recently in liner shipping by some cooperation. Clearly, after all market players carried out a chain of logistic, especially for the regulations and freight rate, trend got started to develop rapidly. To sum up, there are some reasons that why liner shipping service became more popular than the others;

- Growth in worldwide and Asian container shipping market
- Larger vessel sizes
- World economy and its effects on demand
- Fewer pot calls
- Concentration –cooperation
- Development of the container types
- Hub ports and new canals

According to Stopford, main economic principle of liner operation is fixed price with certain route between ports to transport the goods. Replacing Liner shipping has two critical consequences for transport demand. First of all, using bigger ships with improved handling cranes provides for different goods to be used in containers. Secondly, new types of container brought some challenges and reach new costumer such as; packing chicken, ordering wine in suitable condition.

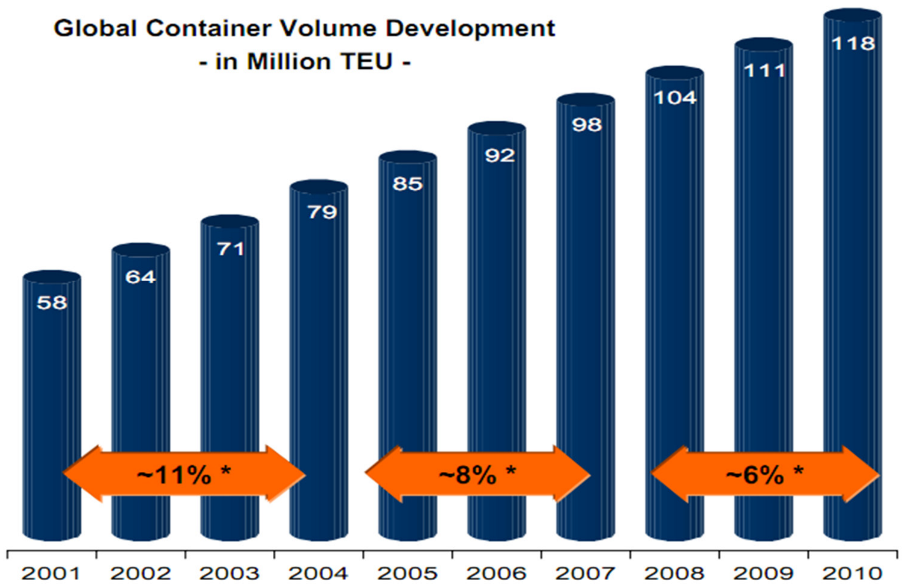


Figure 2.6 Global container volumes (Global Insight)

2.5 Conferences and Alliances

Liner conferences agree on uniform freight rates and other agreed conditions with respect to the provision of regular liner services in a particular trade. Increasing trade volume and marketing demand generated some cooperation and it brought into dramatic changes. Study of ECLAC indicated that Alliances gave opportunities; aggregating cargo capacity, increasing number of service in a year, chartering between liner operator, replacing deployment equipment and building new hub ports. One of the best things is saving time because so many vessels had to wait for formal procedure to be approved by government or agencies ten years ago.

Table 2.2 Development of conferences in the 19th century (Hapag- Lloyd, 2005)

Year	Improvement	Result
1850	Introduction of the first steamship	Capacity increase
1869	Opening of the Suez-Channel	Reduction of the transit times
1873	Recession	Overcapacity and slump in demand
1875	First conference was established	UK-India trade

The most important point will be next conference in 2011 since new environment rules are carried out and according to these rules new vessels will be built and some restriction is going to turn out. 7TH generation of containerships will be friendlier to company's economy and World's ecology. Furthermore, following these regulations require high investment in technologies for new era ships and in order to optimize cost alliances play big role.

Table 2.3 Legal framework of conferences (Hpag-Lloyd, 2005)

Year	Agreement	Place
1916	Shipping Act	USA
1984	Shipping Act	USA
1986	Regulation 4056/86	EU
1998	TACA Decision	EU
2004	ELAA Proposal Published	EU
2005	EU White Paper	EU
2010	New Era	EU

First Alliances was the Europe- Australia in 1972 and operational agreements and joint utilization of vessels approved. It changed dramatically shipping marketing that before this Alliance number of vessels departed from the ports is 9 but for now it is 56 (Hapag-Lloyd, 2005)

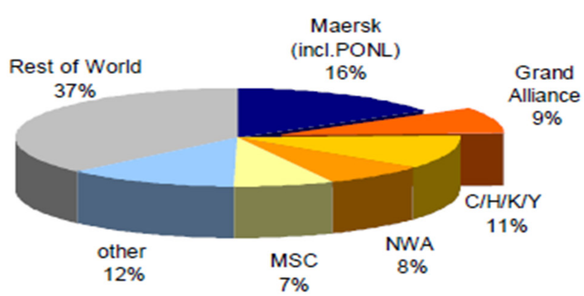


Figure 2.7 Alliances and global players (Hapag-Lloyd, 2005)

It is a well-known fact that there are a few important advantages come from Alliances for companies and customers.

Table 2.4 Benefits of alliances

Benefits for the carriers	Benefits for the customers
Cost efficiency	Wide range of transit route
Joint use of the ports	Saving time to get goods
Ability to coordinate route plans	Sufficient available capacity in all regions
Use of capacity-efficiency	High quality service
Risk sharing for entrance new marketing	Advantages of fair competitions

Alliances increasingly take the control of world's container trade but for a long term there should be new Alliances to design new type of ships. In the new cooperation, supreme service with having most modern fleet in the world with largest number of post panama vessels can be join and then new routes and ports could be set up.

2.6 Routes of Containerships

Scientists have come up with global shipping routes which are based on actual itineraries and there are three major containerships routes such as; the transpacific trade, the Far East to Europe trade, and the transatlantic trade. As it can be seen from the below figure, the busiest route is transpacific route which has over 18 million TEU and 56 loops and these loops offer so many different arrival and departure period for customer and companies (Stopford, 2008). A good starting point is the relationship between containerships and condition of the ports to design 7th generation vessel and it is for sure that number of loops can be changed according to deploying container time and containerships capacity and speed.

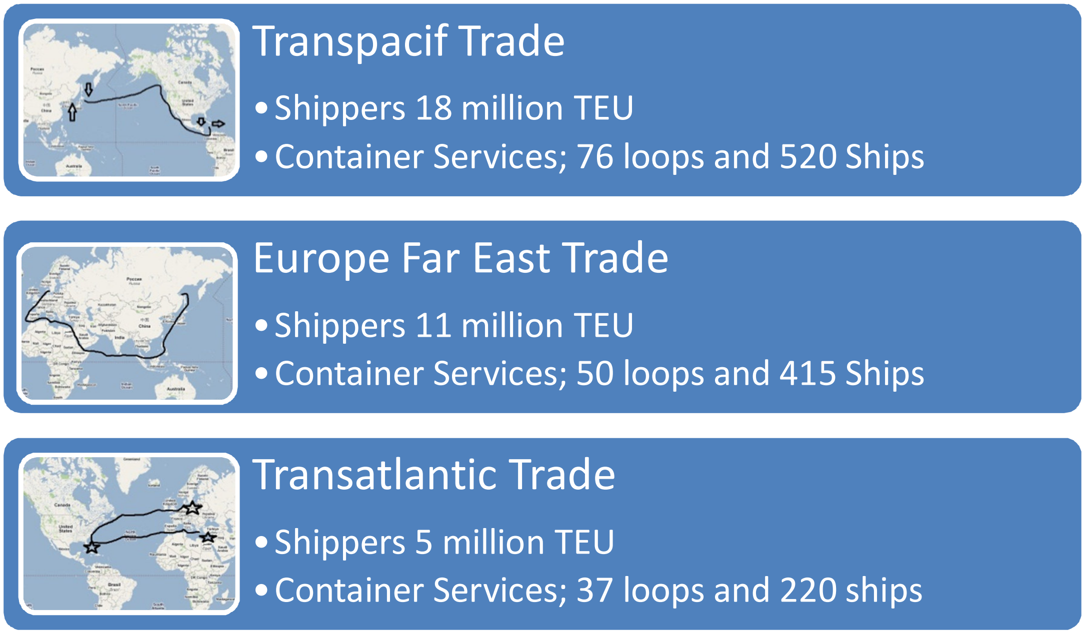


Figure 2.8 Major container service routes (Stopford, 2008)

2.6.1 Transpacific route

The shipping route across the Pacific Ocean, connecting the North America and Asia, has been the one of the most valuable world's ocean path along with the transatlantic routes. One of the most important point is that this route has been controlled a few very big companies and it could offer to cooperate between those companies about new type of vessels. Grand Alliance container shipping lines, Hapag-Lloyd, NYK and OOCl plan to make a new loop to increase profit (Hapag Lloyd).

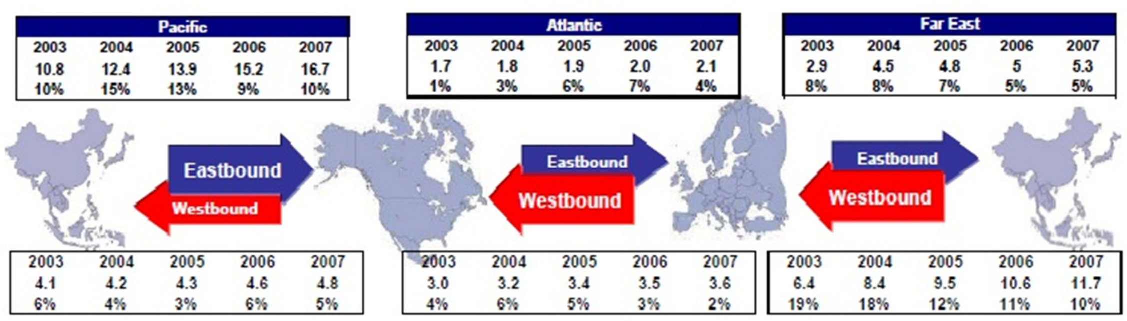


Figure 2.9 Volume of the trade routes(Hapag Lloyd, 2005)

It is shown the figure of 2.9 that from 2003 to 2007 number of container shipped within Pacific line increased nearly 10% every year.

3. LITERATURE REVIEW

3.1. Containerization and World Economy

Use of containers in the whole world for maritime transport has sharply risen over the last two decades. Number of deploying containers was nearly 50 million in 1986 but it peaked to approximately 360 million in 2005 because there is continuous increase trade between Asia and Europe. Containers were represented in the 1960s and it changed concept of world trade. Afterwards, supply chain of marine transportation redesigned and it carried out some important differences such as; shipping lines, transfer facilities, container ports and new hinterland (KIM, 2007). As a result of increasing volume trade, capacity of the containerships and seaport container terminals increased dramatically and liner companies got start to invest huge amount of money for infrastructure expansions. For instance, instead of manually driven cranes, they were replaces by modern and automated equipment and these innovations decreased labour cost and prevent wasting time.

Huge growth of container shipping increased competition between companies and handling capacities of ports got larger. Moreover, to be just in time, new software system used and using of IT-support for logistic control got big role (Wang, 2005). "Containerization has transformed global trade in manufactured goods as dramatically as jet planes have changed the way we travel and the internet has changed the way we communicate" said Joseph Bonney, editor of the Journal of Commerce. In addition to this, further success came out after modifying ships, ports and inland transportation systems around the world upgraded to meet a new modern standard (APL).

Road and rail containers were used earlier 1950 but it did not become a major element of commerce till containerization era. Large and fast ships were built up and cargo handling-port structure changed dramatically after that railway and inland ways of ports were improved to increase efficiency of containerization (Ekin, 2009).

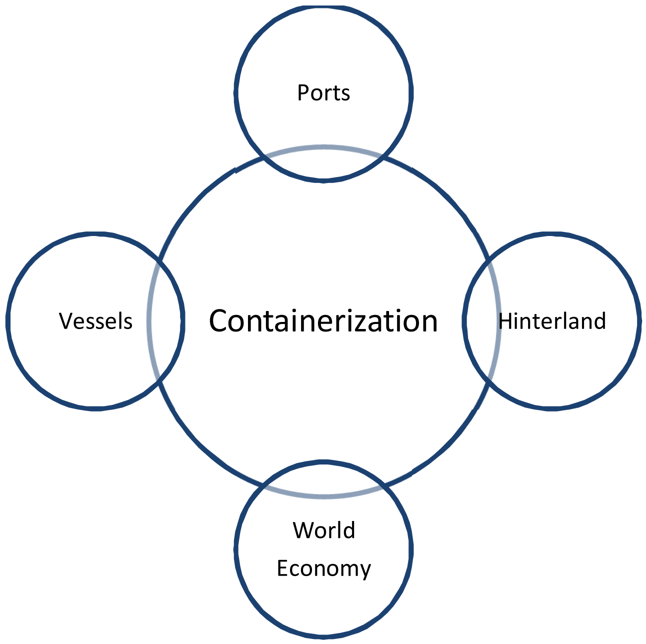


Figure 3.1 Factors of containerization

One of the main reason demand boom of containerization is that companies offer to customer different options and specification of containers such as;

- Open top bulk containers
- Open side containers
- General purpose dry vans
- Platform containers
- High cube pallet wide containers
- Containers with temperature controlling facility
- Tank containers

In the study of Harmeet Kohli, Container traffic on transpacific and transatlantic routes are estimated to grow rapidly within next five years and Asia’s share of containerized exports is expected to reach about 64%. All these information shows that container transportation has played a major role in international trade.

3.2. Supply and Demand Chain of Container Transportation

IMF (2010) reported that for the next decade the structural link between growth in container shipping marketing and world's economic growth will remain basically unchanged. They have some assumptions before they lead to this study and they discovered that some points of the world such as; South America, Far East Asia and a few African countries will play big role on economic growth. The resulting of economic estimates constructed main stages of future rate of growth for marketing, reasonably, they are optimistic but these came from last decade values. In addition, IMF papers reviewed container volumes according to rate of imports and exports. Besides, the information is gathered different countries and independent equations which give us almost real results.

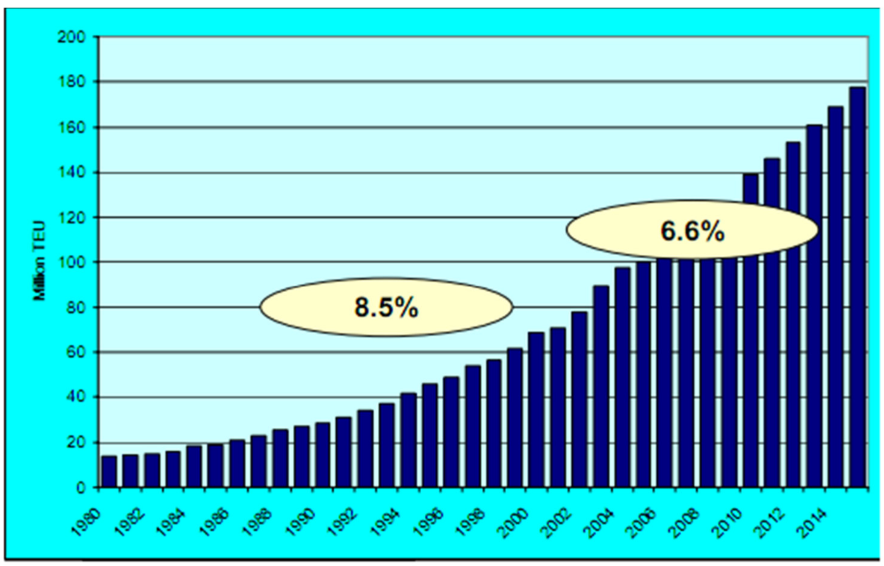


Figure 3.2 Past and forecast container volumes (UNESCAP-IMF, 2007)

Figure 3.2 shows the global container volumes throughout the world but empty containers are not included and each container is counted just one time during the whole journey because containers are handled so many times in a year. One of the major result from IMF study is total number of loaded containers is estimated to rise approximately 235 million TEU by 2015 and the compound growth rate during the one decade (2005-2015) will be nearly 7.6.

Main supply-demand chain goes on between Asia and America and North-East Asia is the most significant player of container trade with placing 50 percent. Furthermore, North America and Europe situate for 35 percent of container volume but according to ESCAP (2010) study trade will be nearly 47 percent end of the 2015. This report also indicates that some regions such as Kazakhstan and India will play major role for exports and imports in 2015 while Chine's trade volumes increase dramatically.

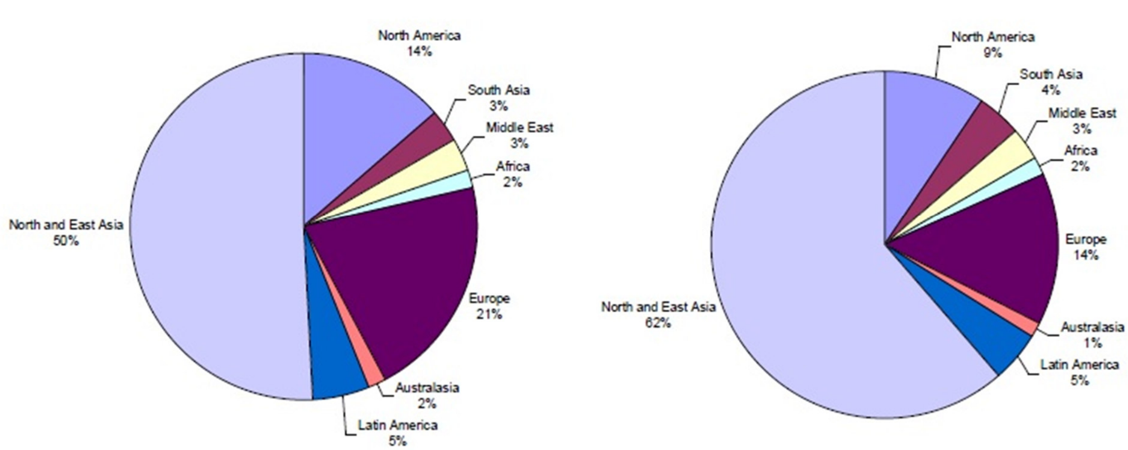


Figure 3.3 Regional share export trade (ESCAP, 2007)

"2011 market volume growth in the container does not change the overall trend of steady increase, the container market supply and demand is relatively stable, but here is still excess capacity, pressure, supply and demand situation is not better than 2010" Han Chemgmin, general manager of COSCO Container Lines Company Limited, put into words this result on November 30 at the conference.

Hpag-Lloyd (2005) study demonstrates that liner shipping industry has some supply chain congestions;

- The overall supply chain congestion remains a major point as effectiveness of global supply is heavily reduced by delays
- Shipping cost increase because of vessel's speed and seeking
- Container volume increase and port infrastructure become bottleneck for rate of growth
- New investments for inland ways
- New hub ports

3.3. Containership Operational Costs

One of the difficult things to calculate total costs of operation is determining shipping marketing condition and freight. According to German Study in 2007, which is done on the operating costs of German container ships, central total costs increased nearly 6 percent in 2007 as compared to 2006. The most significant result is that operating costs increase over 10 percent, particularly, ship clusters demonstrates a wide range of cost increase rate. As a rule, smaller ship sizes draw higher line than larger ship sizes. It is clearly shown in this research larger ship can decrease risk of price fluctuation. Factors of operational costs are classified in different stages;

Table 3.1 Evaluation operational cost of container ship (Bettina, 2007)

Evaluation Perspective		Factors	Effect rate
Cost Pool	Single Cost Item		(%)
Manning costs	Manning costs	Wages, victuals, social and other expenses	33-36
Insurance Costs	Hull & Machinery Protection Loss of Hire Other Insurance	Hull & Machinery Protection Loss of Hire Other Insurance	27-35
Maintenance and Repairs	Repair Outfitting costs	Deck & Machinery Repairs Deck & other outfitting	28-35
Wharfage/docking/class costs	Wharfage/docking/class costs	Inspection, monitoring, disposal, charges and training	5-15
Off-hire costs	Off-hire costs	Port costs, towing, bunkering and other travel costs	2-5

Vessina point out (2007) that even there are some factors for operational costs but manning, insurance and maintenance cost play critical role with 37%, 14% and 32%. Furthermore, ship age and length of vessels affect total cost because of insurance and maintenance. The below figure shows how length of the containership change manning costs change.

Even though port cost, canal charges and navigation expenses are not included for operational cost estimates they can be vary markedly from terminal to terminal (Hutchinson, 1982). Optimizing operational cost can be various ways such as; increasing volume capacity, using more efficient engine, modern ports, new equipment or other sides.

Maersk Line decided to use Microsoft software program to decrease operational using by new and the most efficient routes for fuel consumption. “We saved about $102 million in 2009 from fuel saving and other efficiencies through the transparency we had using the COMS application the Microsoft platform” says Conradse, director of Situation Room- Maersk.

Table 3.2 Manning costs (Bettina, 2007)

Capacity (TEU)	Cost per working day (USD)
Less 900	2900
1200	2200
2000	1540
3000-4000	750
4000-5000	650
5500-7500	560

The relation between manning costs and container capacity is distinctly shown and during the 7 years it fluctuated ranging from -17 to + 14 percent for German Container Ships. In addition to this, insurance displays different rates for each year and there are two significant references for insurance; fair market and vessel route afterwards fleet insurance and certain conditions can be carried out by insurance holder and ship owner. If we compare two container ships which have different capacity 900 TEU and 7500 TEU and then we can clarify total saving between them. For instance it cost about 440 $ for 900 TEU but insurance price come out nearly 1300 $ for 7500 TEU. It is clearly shown in Bettina study (2007) there is a really big advantages serving larger volume of ships.

It is given more detail in fifth chapter how operational cost calculate and what kind of factors there are for “ultimate size of the container ships”.

3.4. Classification of Containership Sizes

All container ships are in principle of open construction in order to access containers with lifting equipment and these vessels are designed as a double hull for convenient deploying (Deveci, 2008). Older type of containerships were sufficiently equipped with powerful lifting and loading operating gear but new kinds of vessel do not need to be designed as it did before because terminals have modern cranes and lifting-loading systems.

Container ships are generally classified into 6 generation according to their container capacity and after second generation vessels got started to build up without lifting equipment and it supply to load more containers. World marketing conditions have been changed dramatically and new dimension demanded to be served afterwards, in 1996, sixth generation container vessel were build which has over 8,000 TEU capacity. Moreover, Mearsk Liner Company has already ordered mega container ships in 2010 and their volume increased almost double (Mearsk, 2011).

Panamax: The name, not surprisingly, came from Panama Canal and This Authority does not permit vessel whose width is larger than 32.26 meters or 12 meter draft limitation to pass through Panama (Chan et al, 2000). This type of vessel has been redesigned during three decades, especially, its capacity increased toward to height and maximum ship length reach nearly 300 meters with 12 meter draft. This type of vessel generally can stack 13 rows of container on deck and this is derived by rubricating 32.26 meters by 2.438 meters (container's width) (Chan et al, 2000).

Post Panamax: The next class of containership is the Post-Panamax containership as these vessels are very big to pass through the Canal, hence the name "Post-Panamax". Their volume capacity range from 4,000 to 5,999 TEU in capacity and 16 rows of container can be loaded up across on deck. In the point of economy scale, the primary objective of the mega ship is saving more money. Furthermore, operating cost of the ship which has 6,000 TEU is not higher than the vessel has 4,000 TEU (Global-Security, 2010).

Suez-Max Ultra Large Container Ships (ULCS): Even it is intended to increase the depth of the canal before 2010 in order to allow the largest ship to be built, the Suez –Max canal is about 163 km long and its width range from 80 to 135 meters. This type of vessel has some specifications such as; its breadth 50/57 meters, corresponding maximum draft with 16.4/14.4 meter which may just meet the Suezmax size (MAN, 2004).

Post-Suez-Max: Even though Post-Suez-Max investigations demonstrate that it could be possible to design the ships as big as 18,000 TEU capacities, Maersk Company has already ordered 10 mega ships (Maersk, 2011). It is claimed by shipping marketing authority that this size of containership can decrease transportation cost approximately 30%percent per container if we compare the vessel which has 5,500-6,000 TEU capacity (Global-Security, 2010).

Post-Malacca-Max: Although only Singapore and Rotterdam container terminals have 21 meter draft, with the intended increase the cross section of breadth and depth of the Suez Canal over the next decade and it is going to be possible to pass through the Suez Canal with 18,000 TEU capacities (MAN, 2004).

3.4.1 Ultimate size of container ships

It is a well-known fact that there is a very big competition between liner companies and each member try to put up new idea and "ultimate" size of vessel in order to obtain new opportunities. Because of the extraordinary amount of time required to plan, fund, and constructing large infrastructure project, it makes sense to start planning for mega containerships (Bomba et al, 2001).

According to research of Wall Street Journal by Rustkoski (2009), ocean freight is now facing major significant problem that demand start to be lower than supply and it makes profits falls down. Wall Street support this idea by speech of Maersk manager and Maersk announced that it will remove 8 6,500 TEU vessel from service until 2009. However, major ports in China reported growth of 10 percent after that companies start to build mega container ships to be sailed between busy points (Rutkoski, 2009). In theory, bigger ships could be built, but there would have to be ports big and deep enough to handle them. In the process of time, new hub ports are built up and they start to deploy large ship. Although Emma Maersk is largest container ship in the world, Maersk Liner Shipping Company has already ordered the vessel which has nearly 18,000 TEU volumes.

Table 3.3 Some large container vessels

Name	Capacity (TEU)	Length (m)	Beam-Draft(m)	Speed (kn)
Emma Maersk	15,500	397	56x15,5	25,5
CMA CGM	13,344	365, 5	51,2x15,2	24,3
MSC Beatrice	14,000	366,1	51x15	25,2
MSC Francesca	11,600	363	46x14,9	16,3
CMA CGM	11,040	347,48	45,02x15,50	24,8
Hanover Express	8749	335	42x12,9	20

The traffic growth implies a trend for bigger containership and technical improvements allow designing larger ships in order to obtain the lowest total cost per cargo ton. Here some advantages of using larger ships:

- Larger size of container vessels can reduce the number of port calls
- These ships work as part of a global network and they imply extensive use of transhipment
- Improve port competitiveness with information technology
- New routes have discovered and network pattern changed
- Port investments rise and hinterland ways improve (Lorthiois, 2008)

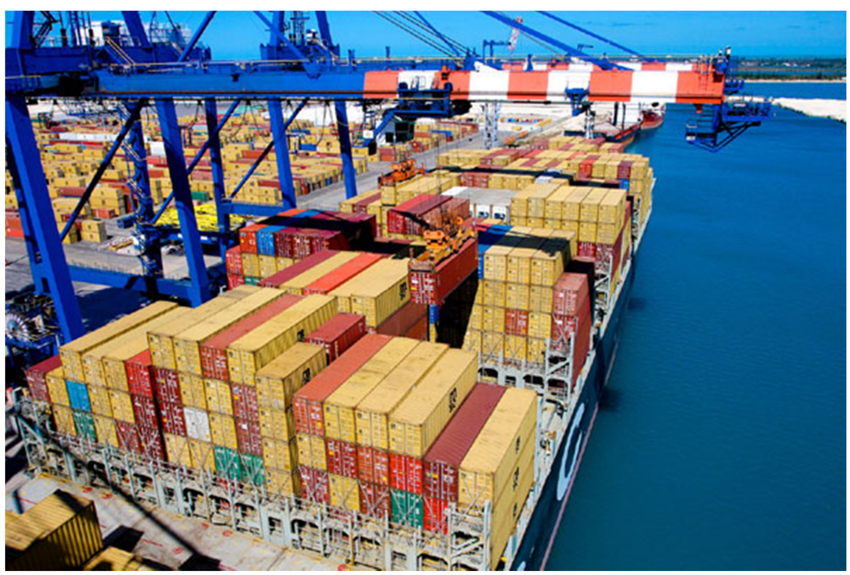


Figure 3.4 One of the hub port with large containership

3.5 Port Infrastructure Requirements

A ship spends its major amount of time at port. One of the most important factors for efficiency is cargo handling rate and it allows for ship size to be built larger size. Better cargo deploying rates means that saving time in port for the carriers. Besides, number of port calls can be lower because of the larger capacity of the vessel. Almec (2002) mention in his study that port facilities can be vary from region to region on depend on the ships and cargoes being handled. In the study of Almec, it is also pointed out that port facilities has number of specifications; draft of terminal, number of berths , berths length, types of cranes, other equipment and location of the terminal.

Hub ports require handling containers of mega vessels so that these type of port can be worked as a transhipment status. To become a hub, the port must be located directly on a major sea lane and it should be connected certain route and destinations for quality services of mega ships (Almec, 2002).

As ECLAC states in 1998, the number of port calls by the Post-Panamax and larger vessel can be reduced as long as the additional price for intermodal connections and feeder ships are lower than saving from port calls. In other words, port traffic can be in coordinate with larger ports and it can increase rate of profit for hub ports. Liner shipping firms start to have larger ships to get more advantages, as a result, if ports want to play the role of large transhipment hubs they have to provide adequate infrastructures and necessary equipment to serve mega container ships within short time handling larger numbers of containers (Acciaro, 2004).

According to Drewry Shipping, global container terminal throughput has historically grown at multiple of about four times that of global gross domestic product and it clearly shows that terminal throughput has grown faster than overall TEU’s.

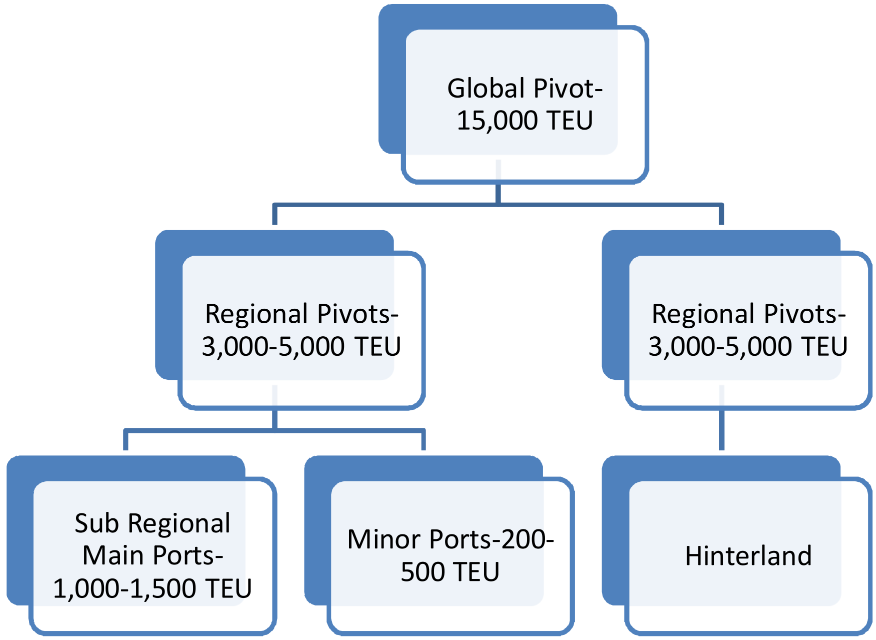


Figure 3.5 Eclac(1998)

In one of the more futuristic approach came from Gustaaf de Monie of Policy Research Corporation (1998) and the best places of "mega hubs" identified in four different regions;

1. South-East Asia
2. Exit of Mediterranean
3. The Caribbean
4. West Coast of Central America

Since trade flow is very busy between Asia and America a few modern hub ports have been built up but rest of the main potential places there is not enough investments.

Table 3.4 Port assets classifications (World Bank, 2001)

1.Basic Port Infrastructure	2.Operational Port Infrastructure
Maritime access channels	Terminals
Port entrance	Quay walls, jetties and finger piers
Shore protection-breakwaters	Docks
Sea lock	Port land
Hinterland-rail connection	Access roads to road infrastructures
Inland waterways within port area	Rail connection to rail ways
Inner port channels	Roads , tunnels, bridges
3.Port Superstructure	**4. Port Equipment**
Terminal lighting	Cargo handling equipment
Paving, surfacing	Dredging equipment
Parking areas	Tugs
Warehouses and stacking areas	Line handling vessels
Offices	Ship to shore handling vessel
Repair shops	
Other buildings for terminal operational	

3.5.1 Equipment of container ports

Even though new mega container vessel has sufficiently qualified with technology, there should be major level of trade to support loading/unloading containers. In other words, one of the biggest problems is port time and there must be modern shore side facilities (Vulvovic, 2006). “Hub” port illustrates really good pattern to handle containers properly. Vulvovic also identifies the case of mega container ships with service factors. The terminal must have enough place to accommodate larger number of boxes that will accumulate before the ships arrives; crane capacity, number of cranes, tugs, vehicles.

A debt deal being discussed among experts, Yang (2001) indicates that all-modern terminals operate the vessels by the developments in quay crane technology and the organization of the vessel-quay-yard interface. For instance, in order to handle 12,000 containers within 24 hours so many terminals must increase number of gantry cranes and forklifts. In order to complete loading/discharging work this certain time, 52 containers should be deployed with six gantry cranes which are placed same berth. Furthermore, 35 containers must be handled by nine container cranes are utilized in intended berth. If we look whole picture, it requires increasing equipment more than 200% in productivity through innovations in container handling systems for most of the terminals (Yang, 2001).

To decrease port call and for saving time number of equipment and their type of mission are very important to handle large container ships.

Table 3.5 Terminal equipment (KALMAR, 2007)

Type of Vehicle	Capacity	Mission
Container Handling	7-45 tons	To carry empty containers in port
Fork Trucks	2-30 tons	To move containers though warehouse
Gantry Cranes	40 tons	From ship to shore
Harbor Mobile Cranes	40-82 tones	Flexible container handling
Reach stackers	32-45 tones	To transport container quickly
Terminal Tractors	12-45	For heavy roll on/off goods
Terminal Trailers	3x40x40 tones	To solve traffic congestion in port

4. EFFECTS ON MEGA SHIPS PERFORMANCE

4.1 Introduction

It is very important to understand the major factors which determine the ultimate size of containership. Kendall (1972) points out that optimum size of the vessel will be only to minimize total cost of transportation in a given shipping route. Total transport cost is composed by summation of costs incurred at sea and the port related costs incurred (Kendall, 1972). Research design and methodology will base these cost factors and new approach in formulating a model of ultimate container ship size will be done. Furthermore, data research of the cost items and technical details are selected various sources from the industry and publicly available information like from the internet and publications will be performed to form the data. To sum up, all these findings could be of use to determine ultimate size of containership for existing or future service routes.

4.2 Key Factors for Ultimate Size of Container Ships

Liner industry has been really expanding its capacity and moving new type of ports which are suitable with mega containership but there are some issues to clarify (Stopford, 2002);

1. **Trade outlook**: it is clear that ships size depends on trade volume and we should put commercial relation of vessel to design ultimate size of vessel
2. **Economies of scale in shipping**: even though container shipping business looks restricted trade to the others, other parts of the industry can affect size issue.
3. **Trends in containership size**: necessary data should be reviewed from the first containership built up to close future of liner shipping to clarify certain size.

4. **The economics of containership size**: the profit of company should be carried out for how much unit transport costs be reduced by taking another put up in ships size.

5. **Implications of ship size for the global transport system**: transport system and its methodology could be developed and systemic applications of ultimate size can be studied.

McConville (1999) emphasize in his study that optimum cost characteristics of containership size depend factors like the dimension of vessel, speed of vessel, the voyage distance and time period of voyage.

Dimension of vessel: It has been accepted by economists that bigger volume ship has better cost efficiency. "A ship's carrying power varies as the cube of her dimensions, while the resistance offered by the water increases only a little faster than the square of her dimensions so that a large ship requires less coal in proportion to its tonnage than a small one. It also requires less labor"   Marshall (1990). In addition to this, most port dues are dependent on ships size, length overall, and the gross tonnage.

Speed of vessel: It is a well-known fact that when ship's speed increase, it is resulted higher fuel consumption and vessel's speed is limited by the ship's designs to get better efficiency. Speed affects a total round trip time, increasing or decreasing speed will affect the time spent at sea which indirectly affect the time spent at port for container handling.

Voyage distance: When the trip distance in nautical miles is increased, it will increase the bunker consumption and operating costs given a fixed vessel and speed.

Port time: Cargo handling activities and its time are very important for liner shipping companies. If the cargo handling facilities provided is efficient, the port stay time period will be short and it makes contribution to port authority for number of port calls. A congestion terminal will increase the port time and it is also crucial that number of berths is important because it can allow vessels to accommodate in berth with moored. Time period of goods shipped by vessel is vital and co-ordination between port and ship should be appropriate to handle container in certain time. Likewise, spending more time at port will also mean incurring higher port related costs. As it is mentioned earlier, the total sea transport cost includes the ship costs and terminal cost, affect the size of ship (Stopford, 2009).

The typical cost structure can break into three groups;

1. Voyage costs: it is a cost related to performing a round voyage and items will be fuel costs, port dues, canal dues, cargo handling costs and crew expenditure. These costs can be avoided if a voyage is not performed but main expenditure component is fuel cost which is directly dependent speed of vessel, price of bunkers and the distance. A longer port stay will cost much more money and cargo volume to be handled, mooring-unmooring, berthage, pilotage and towage are participated to port cost.

2. Direct operating costs: one of the main items is insurance which can be covered by ship's hull and machinery system and there are some different type of insurance which are; war risks, protection and indemnity insurance. Moreover, crew costs, repairs and maintenance, stores and administration expenditures have minority if we compare to insurance.

3. Capital cost: main future of this type cost is being fixed as it does not vary and capital cost is incurred by ship's owner. In the case of ship operators, ship can be operated on a time-charter basis as the operator may not be the owner but the ship charter has to make fixed payment to the owner for time-charter basis. In the study of Stopford, capital costs occupy nearly 42% of bulk carrier and it costs up to $200 million for building mega containership and capital payments dominate shipowners' cash flow and affect their investment decisions. Larger vessels are more sensitive to their own cost change than smaller ones.

As it is seen from below figure, second top investment is big containerships and there are 567 vessels over 3000 TEU costing $63.3bn on order. The trend of containerships' size has been increasing up to 18,000 TEU and investors have punted that container transport is a margin game which the big ships will win in the long run (Clarkson, 2011).

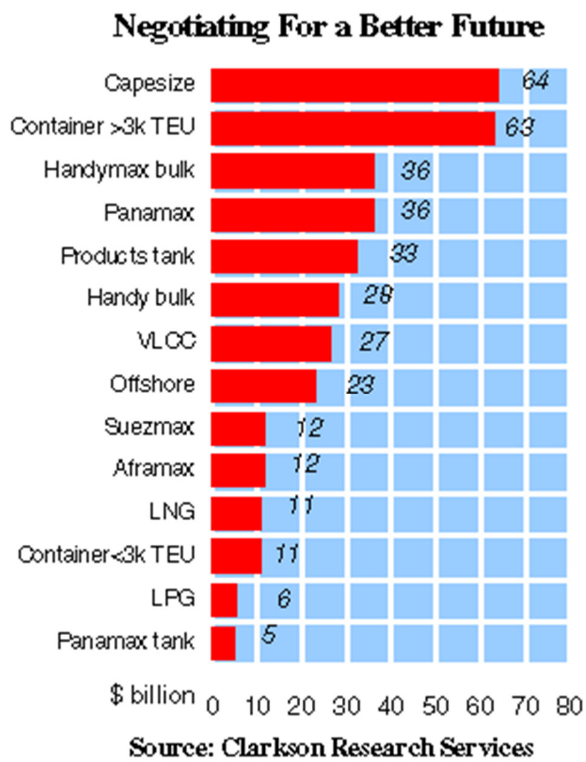


Figure 4.1 Order-book of ship-owners (Clarkson, 2011)

4.3 Existing Shipping Marketing Conditions

Liner marketing has been controlled by very big companies and, in the course of events, companies started to join Alliances and new stronger global player came out. Small firms has lost their power to invest huge amount of money and Grand Alliance, Maersk, C/H/K/Y, NWA, MSC control approximately 60 percent of marketing volume so we can call containerization market is kind of oligopoly industry.

The early system of liner shipping was kind of an oligopolistic supply which could be more competitive demand part and it was hard to affect liner rates. Today's shipping point of view has been changed almost totally and new marketing condition can be called as a bilateral oligopoly. It means they have organized and some major agreement and cooperation are done for new market structure (Gust etc. 2006).

In the current market environment, shipper remain concerned about the viability of ocean carriers, specifically, shipping companies ability to go on adequate service levels to handle containerized export and import needs. In the article of Fussilo

(2011), it is mentioned that liner shipping firms have long discussed that task of supplying adequate service to shippers whilst earning reasonable rates of return on capital requires at least some particular form. Scheduling requirements of liner shipping firms constrains firm's ability to adjust capacity to satisfy market conditions. He also touch on how rigid liner shipping capacity is turned out and import trade lanes curve exhibits more flexibility than other industry factors. Competition of liner shipping is a fact that great concern can be carried out for alliances in the trading world. This partnership works to decrease some expenditure; transport cost, number of port calls and others. Vessel sharing agreements (VSA) supply to increase efficiency and it changed economic scale of shipping (Hernandez, 2006). Shipping firms have been working on transport cost and their main goal is decreasing percentage of the value goods. Moreover, containerization has been spread throughout the world since so many container ports have been built up. As a reaction of this trade growth, the many maritime carriers added capacity to their existing volume to reach the demand. In the article of Hernandez (2006), number of liner shipping agent has been rising which is possibly decrease freight rates and this decline could be done by quality of service, transit time , volume of ships, door to door services.

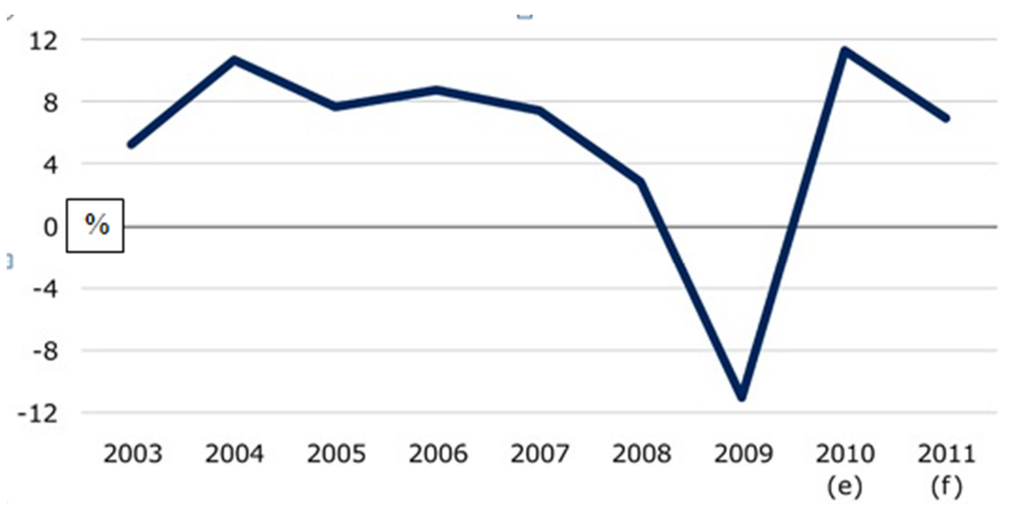


Figure 4.2 World trade volumes of goods and services (IMF, 2011)

Great Eastern Shipping Company, the largest private shipping company of in its country, has dropped plans to approach capital market to raise funds through initial public offering shares because the company has cited bad market condition for the decision (2009). It has been taken time to fix and re-schedule their new program to reach the goal. Clarkson study, below figure, indicates that average global container freight rates saw a major rally in late 2009 but it has continued up and there will be nearly %8 increasing within 2 years. The biggest problem was exceeding demand volume and freight rate declined to make ships awake. On the other hand, although number of containership orders got down during global crisis period it has got good pattern to go up, especially, so many orders type are composed by larger vessels.

Ocean carriers and owners are estimated to have spent around $100 billion on containership orders between 2006 and 2008 but whole plan was changed by global finance crisis and it took too much time to recover from that situation because so many shipyards were almost done and shipping companies did not earn enough money to invest new ships.

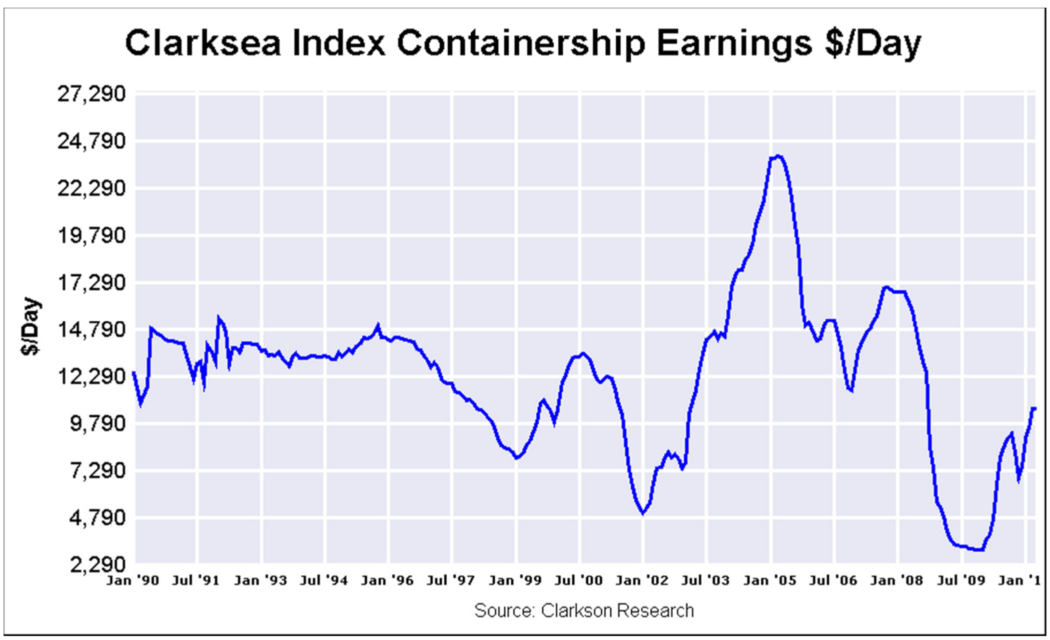


Figure 4.3 Containership daily earnings from 1990 to 2011 (Clarkson, 2011)

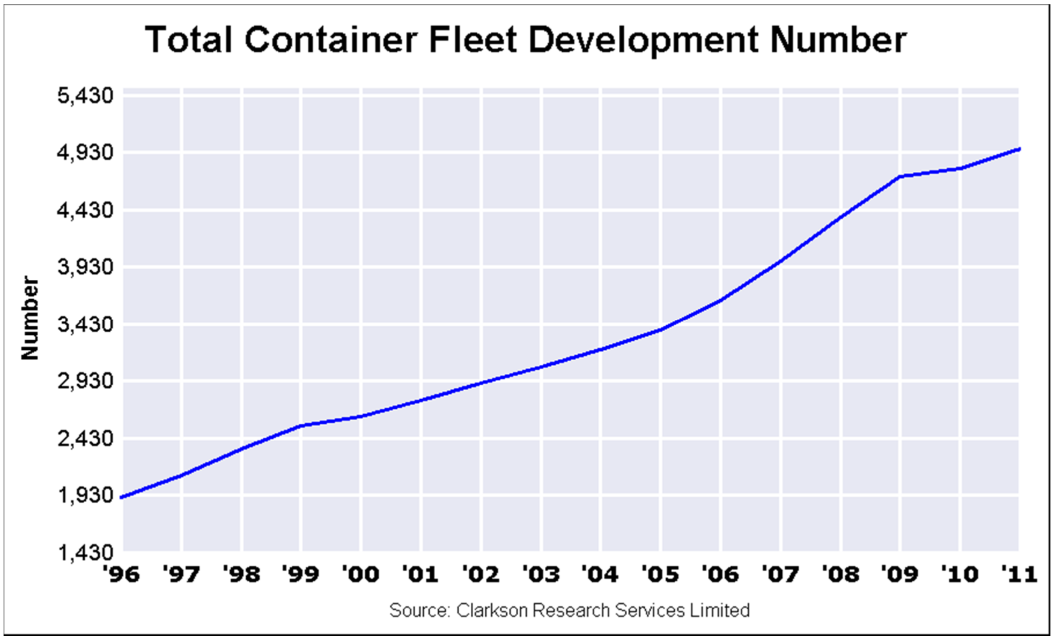


Figure 4.4 Total container fleet development number (Clarkson, 2011)

Container Shipping: The industry reached the deepest bottom in the first part of 2010 and freight rates went down for nearly six months and third part of the year volume was started to move up. This positive movements changed laid up tonnage, however, new building constantly coming on stream and it come out new problem of overcapacity. In the first quarter of new year, freight rates and demand started to increase with new acceleration since consumer's shopping and more jobs in the EU and US went on. Number of containerships order, of course, reacts slowly down and yard capacity is expected to grow slightly (IMF-BIMCO, 2011). In other words, it is clear that the outlook of next three years is scary because of overcapacity trade volume. Even though trade got started to be distortion and damaging for world, liner shipping marketing has created new approach to make economy alive.

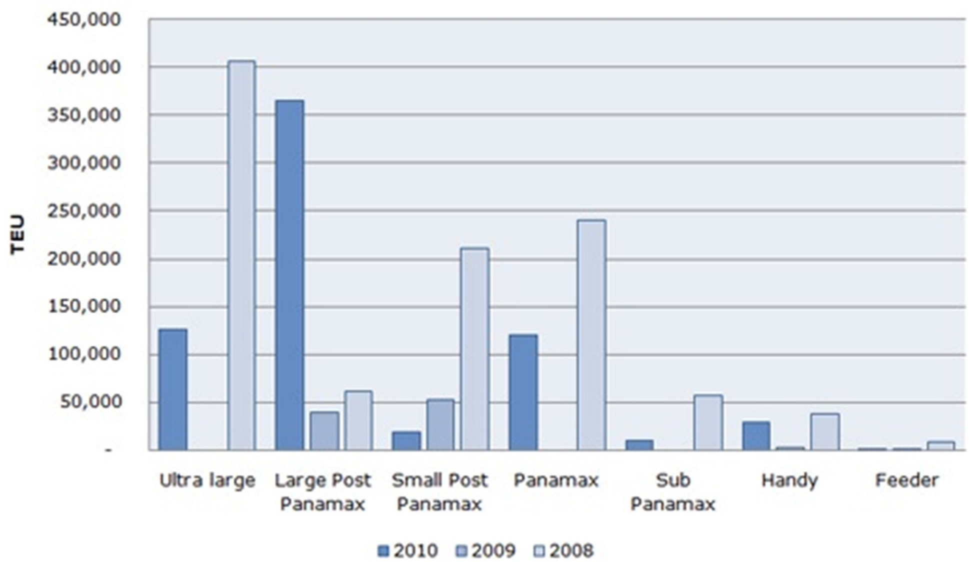


Figure 4.5 New containership orders (BIMCO, 2011)

As we can see above figure, the most demand ship in 2010 is the large of Post-Panamax vessel which range from 7,500 to 10,000 TEUs. This type of ships are serviced the trade between Asia and Europe lanes as well as extended transpacific trade lanes connecting to other parts where they work quite low demand in 2010. Then, Evergreen signed the contract for 20 vessels of 8,000 TEUs which cost 103 million each at Samsung Heavy Industry after that Daewoo got order 10 vessel of 8,400 TEU capacities by 98 million each. To sum up, there is clear upward shift for size of containerships and new supply pattern can be defined by them.

Considering of containerization marketing to understand what happened in liner shipping markets, some very large capacity companies grow faster than the others and six biggest stevedoring firms increase rate of share. Besides, some stevedoring companies controlled directly small shipping lines ant they entered the way vertical integration took place (Pierre, 2008). According to BIMCO, container fleet has grown by 3.2 % during the first period of 2010 and it can be also seen from this report that volumes of Far East to Europe lane pattern reach 21.2% in the first quarter and this positive perspective brings some innovation like ultimate size of containership and new investment.

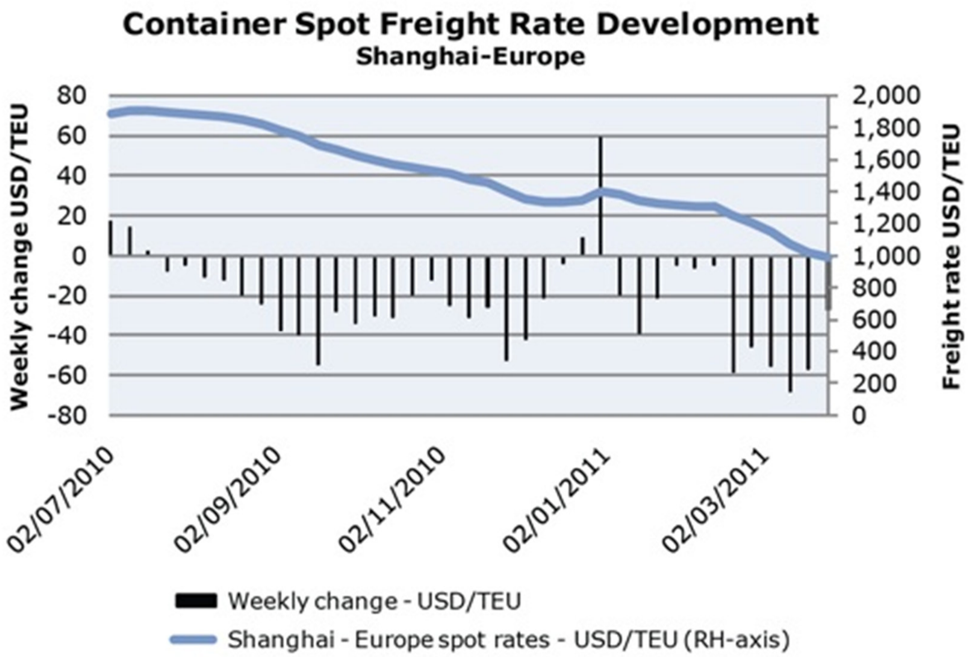


Figure 4.6 Freight rate of certain region (BIMCO, 2011)

Since liner services revolve around the world in a complex network of routes and generally overlap, it is really difficult to define their price way. As a consequence, liner shipping marketing has been fluctuated since economic recession came out ant it will take time to be recovered from this situation.

4.3.1 Requirements

In the shipping marketing, there are some obstacles which should cope with them but self-industry power cannot handle to solve certain problems. For example, maritime transport trade plays a big role in internal and external economy of the country and it should be attracted by attention of government. To construct structure of management, government can invest more sources to the ports and new maritime policy could be brought into being to increase and support the competition between countries. In the research of Freightwise (2006), general requirement of marketing can be broke into three groups;

Infrastructure: To begin with, pressure on road freight has been increasing for a long time, also, new tough regulation, higher fuel cost and congestion of ports show some proof for different point of view. Although fleet is increasing in the process of time in terms of number of ships, hinterland connection and railway requires urgent invest to deal with increasing volume of trade.

Motorway of the Sea: Demand for such services must be determined correctly before investments are made because one of the main aims is that reducing congestion and increasing efficiency but sea leg should be connected the way efficient inspections will come. New transport corridors can be drawn so that supply chains operate faster and carried out more prolific strategy.

Building up Railways: To satisfy customers, deliver time of goods must be in a certain time and one of the best things to be done is laying down more railways. Not only it will save time but also liner shipping marketing and logistic company will be more competitive in order to increase its market sharing.

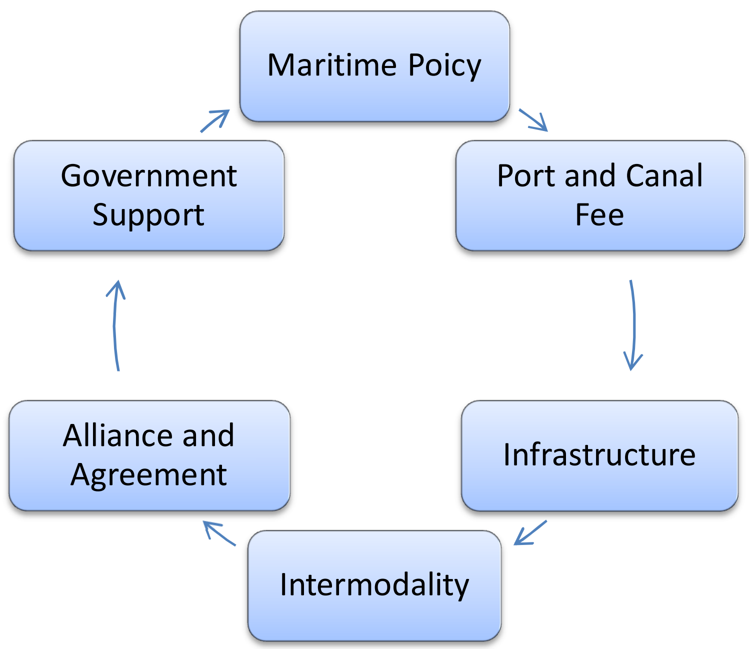


Figure 4.7 Some requirements of marketing

As Hernandez (2006) points out that equipment and structures of ports should be sufficiently qualified to serve larger ships and new policies should allow shippers to work accordingly as well.

4.4 Types of Containers

There are numerous designs of shipping container and these containers must be confirmed to international standards such as ISO or UIC. ISO containers can be used in different transport mode such as; truck, rail and ship. There are some configurations of them:

- Dry ISO containers
- Insulated or thermal containers
- Refrigerated containers
- Flat racks and platform container
- Open top containers
- Tank type containers

All these containers are manufactured in standard size by these values;

Table 4.1 Types of container (MCM, 2011)

Name	Dimension	Mission
Ventilate container	20’	cargo requiring ventilation
Bulk container	20’	Ideal for bulk cargoes
Tank container	20’	For carrying liquid chemical
Dry freight container	20’ and 40’	General purpose
High cube container	40’ and 45’	Designed for over height volume staff
Open top container	20’ and 40’	Removable awning for top
Flat rack	20’ and 40’	Suitable for heavy and over width cargoes
Insulated container	20’ and 40’	For necessity of insulation of goods
Reefer container	20’ and 40’	For stable temperature-cooling-freezing
High cube reefer container	40’ and 45’	Useful for over height and requiring cargo cooling

Above container types will be account into designing volume of ultimate containership size. In addition to this, some parts of the vessel have to perform for reefer container types and addition engines and systems are required for this.

4.5 Hub Ports and Their Infrastructures

The hub port concept can be defined as two types which hold major affect for marketing; centrality of retaining a mega hinterland and being centre of cargo handling. However, in case of appearance of mega size containerships, the intermediacy characteristic of the hub terminal will be more important (Yang, 2006). Besides, hub port location plays a big role to be controlled by regions and there are three major spots of the world to design mega terminals such as; America (East), Europe (North and South) and East Asia. For instance, In order to create hub port in North East Asia, it must be located near to Japan, Korea and China because transporting cost of the feeder ships can be lower than other places as we remind most of the goods flow from Asia to the World. Moreover, to build hub port, hub port facility and its system should perform excellent service; working on time and guaranteeing safety. Finally, liner shipping companies look for lower cost of transhipment in the hub port so this cost must be minimized by port management.

Table 4.1 Major hub ports and their regions

Asia	Europe	America
Singapore	Rotterdam	Los Angeles
Shanghai	Antwerp	Long Beach
Hon Kong	Hamburg	New York
Shenzhen	Bremen	Savannah
Busan	Valencia	Santos
Guangzhou	Felixstowe	Oakland
Dubai	Algeciras	Virginia

The route of ship plays a big role about bunker costs and service time since there are sufficiently enough qualified hub ports. “Ultimate” sized is going to have particular limitation but transpacific and transatlantic route will be appropriate sailing between these regions.

Experts in Shipping industry put forward three main factors selected for liner companies marketing and each category has own parameter (Hwang, 2005).

- ✓ Category A: internal factors of ports, handling equipment, total length of the berths, draft of harbour, efficiency and service quality.

- ✓ Category B: external factors of the ports, location of the terminal, inland transportation infrastructure, number of obstacle to reach other closer region, feeder routes.
- ✓ Category C: operational factors of shipping lines, maritime policy, alliance type, preference of mother ports, ability of agent.

The increase in volumes of turnover, vessel sizes and demand of faster service better facilities stimulate the development of larger, faster and more modern container terminals. Besides, there are a lot of question which are arisen such as;

1. How to design and construct the quay?
2. Which gate systems to handle the inland flows in a secure way?
3. What types of container cranes will be necessary?
4. What kind of automation system to adopt for providing unceasing handling?

As Yang (2003) indicates in his study that shipping companies always try to get handling and stevedoring just in time in order to reduce their port time as the vessels become larger. However, some of the mega ships might request to be changed their calling port to nearby terminals because they would like to get higher efficiency. On the other hand, high technology port handling and operation system perform the biggest role on shipping marketing. Advanced hub ports are implementing development, improvement and investments in different fields; new modern port design, reengineering existing port, and new equipment to increase efficiency. Among these the first priority of improvement should be development of new concept port system in order to prepare ultimate container ships. Automated intelligent operation vehicle and unmanned handling system can prevent wasting time. Besides handling system, some of the hub ports structure cannot meet required productivity by mega ships and new concept of hub terminals is came out and started to design such as; floating terminal and indented berth.

After major terrorist attack, awareness of control over imported cargo has been increasing throughout the world and some inspection are brought into account ; controlling by X-ray, visual inspection, product tests and new type of policy. These mentioned factors definitely increased the transportation cost and port facilities try to solve this process within certain time.

Tongzon (2009) generalized main groups of port choice as they can be presented in the table below. When mega container ships visit the ports there is no additional minutes to spent like policy of port, breakdown of vehicle, service period and infrastructure system.

Table 4.2 Major factor to choose the port (Tongzon, 2009)

Visiting ship number	Offers more options in scheduling are based on competition and it allows flexibility for transit time.
Port efficiency	Speed and quality of terminal can get role in the freight rates and operational efficiency may be affected by labour system.
Adequate Infrastructure	Especially for hub ports this is one of the major factors and number of berths, gantry cranes, and maintenance service and information system construct the port quality with hinterland ways.
Location	Ultimate size ships should be sailed between transit points.
Port Charges	It is based on port visits period and some items are very important for shipping company such as; berth hire, berthage, harbour dues, pilotage, and mooring.
Quick response to ports user necessity	Being in time and satisfying customers can affect service quality.
Insurance for cargo damage	Positive approach of the port can improve the port's reputation in order to be in the marketing dues.

4.5.1 Case study-PSA Singapore port

Singapore has long been recognized as having one of the most efficient hub port for mega ships and busiest port in the world with having capacity nearly 35 million TEUs. It is important to note this achievement comes with many changing throughout the years and investment to equipment and port's infrastructure played big role.

It is reported by PSA Singapore Port (2010) that despite bad circumstances of the global economy, Singapore is still the world's busiest container port ahead of Shanghai judging by statistics from port authorities. However, Singapore container port suffered a 13.5 per cent fall in container marketing in 2009 and volume of handling container decreased to 25.14 million TEUs. Afterwards, PSA Company understood to have offered discounts to some shipping companies to handle the finance problem and the company has also delayed some projects (PSA, 2010). On the other hand, when the global economy has started to recover very well export growth continue to rise and number of container which is handled has been increasing. Singapore terminal was the busiest port till the global crisis but during the recovering time news reports from China that in 2010 Shanghai's total container throughput overtook Singapore's to make it the world's busiest container port. Container traffic was up from 24.8 to 27.9 million TEUs and it means 532 million tons were handled. One of the important things is that Singapore looks set to maintain its lead as the world's busiest port in term of shipping tonnage, the world's top bunkering port and major container transhipment hub (SA, 2011). It is also reported by SA that Singapore port authority spent approximately $1.4 billion to increase its port annual capacity and they try to serve larger mega ships.

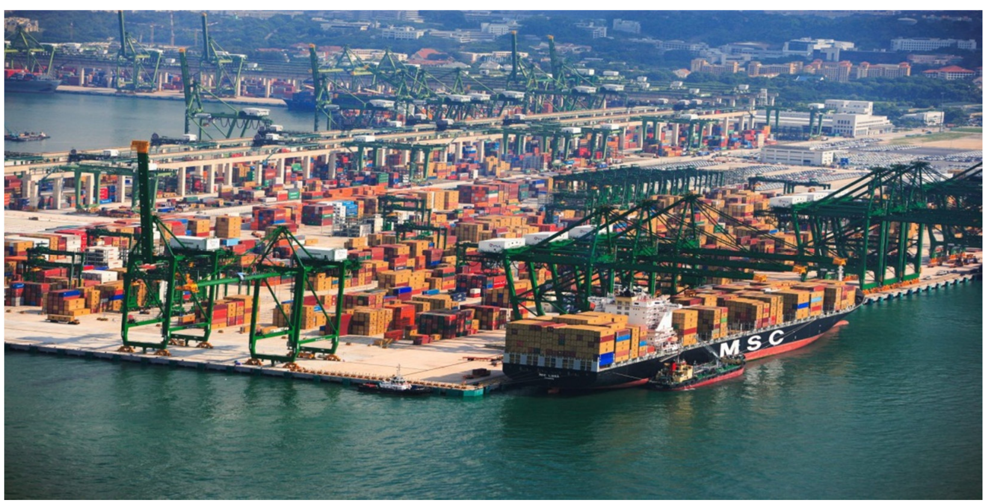


Figure 4.8 PSA Singapore port

"In 2010, a convergence of all the measures macro and micro-government and industry-all collectively had the desired effect of calming the global markets. PSA and the port and shipping sector in tandem with all other industries benefited from the resulting outcome. Container volumes recovered strongly from the previous year and, with contribution of volumes from newly commissioned terminals in Busan in South Korea, Chennai in India and Vung Tau in Vietnam, PSA Group ended the year with a new peak of 65.12 million TEU (14.4% increase year on year), surpassing the previous high of 63.2 million TEUs achieved during the heady and tumultuous times in 2008." said Fock Siew Wah (PSA International). As we look PSA profile we can see that they have power to control many point of the world, especially, mega ships can sail between these points since they have feeder ships service.

The Maritime and Port Authority of Singapore (MPA) was established on 2 February 1996 with the mission to improve Singapore as a premier centre hub port and international maritime centre. MPA is the driving force and support behind Singapore terminal and they take care with safety, security, environmental protection, port operations and services (Wikipedia, 2011).

Table 4.3 Details of port Singapore performance

Year	Vessel Arrivals	Container Throughput (million TEU)	Cargo Throughput (million tons)	Bunker Sale Volume	Singapore Registry of Ships
2006	1.31	24.8	448.5	28.4	34.8
2007	1.46	27.9	483.6	31.5	39.6
2008	1.62	29.9	515.4	34.9	43.7
2009	1.78	25.9	472.3	36.4	45.6
2010	1.92	28.4	502.5	40.9	48.8

Table 4.4 Singapore port operational area information (PSA, 2011)

Container berths	44
Quay length	12,800 meters
Area	436 hectares
Maximum draft	16 meters
Quay cranes	143
Designed capacity	24,700 kTEUs.

In a nutshell, SPA Singapore terminal makes 130,000 ports call for vessel with totalling 1.5 billion gross tons. One of the significant improvements is planning to increase container volume capacity to 50 million TEUs by 2018. In other words, port infrastructures and equipment will be more modern for ultimate size vessels and it will be centre of transhipment business for larger ships (Ekin, 2009).

4.5.2 Case study-port of Rotterdam

Rotterdam is one of the major ports in Europe and the port is the gateway to other part of European market of more than 350 million consumers (POR, 2011). It is also reported newsletter of Rotterdam port that the annual good flows is approximately 430 million tons. The terminal get mission between America and Asia and containers distributes from Rotterdam to the other countries. Annual report of Rotterdam port indicates that the Port Authority invested nearly € 340 in 2009 to recover suffering global fluctuating and € 500 million invested in 2010 to construct new berths. Moreover, € 700 million will invest within one year to improve efficiency of existing port areas.

One of the best spectacular performances for mega ships are shown about new construction and the construction of Maasvlakte is proceeding according to plan and it will ensure that sufficient deep water handling capacity will be supplied nearly end of the 2013. Besides, report of Port Authority (2011) also bring up a matter for ultimate container ship size and they will provide suitable accessibility and cross-river connection will be done within 4 years.

Hans Smits, CEO of the Port of Rotterdam Authority, note that container traffic jumped from 9.8 million to 11.1 million TEUs by 14 percent. Rotterdam expanded its market share on the key Asia-Europe liner as carriers introduce increasingly large container ships that are able to call more easily at Rotterdam than at competing ports.

As a consequence, Rotterdam is doing well in the largest trade in quantitative terms that between Europe and Asia because liner shipping firms combines their services and deployed the biggest possible vessel to reduce cost. Furthermore, the port has some advantages; the location of the port, hinterland, port tariffs and infrastructures of port.

Figure 4.9 Maasvlakte-additional part of Rotterdam port

Table 4.5 Incoming and outgoing TEU's from Rotterdam port (ROP, 2011)

Regions	**Incoming**		**Outgoing**		**Total**	
Years	2008	2009	2008	2009	2008	2009
Europe	1.804	1.455	1.914	1.687	3.718	3.142
UK	590	430	640	534	1.230	964
Ireland	306	264	281	238	587	502
Others	908	761	993	916	1.901	1.677
Africa	158	168	131	135	289	303
South	86	77	52	59	138	136
Others	72	91	79	76	151	167
America	1.005	899	783	646	1.788	1.545
USA	465	382	403	349	868	731
Others	540	517	380	297	920	814
Asia	2.534	2.347	2.288	2.236	4.822	4.583
Hong Kong	215	327	213	287	428	614
Japan	186	114	135	867	321	1.981
Singapore	343	94	326	146	669	240
China	1.191	262	946	181	2.137	443
Others	599	550	668	755	1.267	1.305
TOTAL	5.515	4.879	5.150	4.729	10.665	9.608

Major shipping companies get Rotterdam Port services and they are;

1. Maersk Line
2. Mediterranean Shipping Company
3. CMA CGM
4. Hapag-Lloyd
5. Evergreen

Only about twenty companies use this port, but the market leader is Maersk Line with 20% share and it is expected to increase further consolidation (POR, 2005).

Equipment of Rotterdam Port:

- 12 container cranes
- 22 ship to shore bulk cranes
- 25 floating cranes
- 103 container gantry cranes
- 162 multi-purpose cranes

There are over 90 terminals, 35 reserved for liquid bulk cargoes, 15 for dry bulk cargo and 17 for multi-purpose. The terminal has also nine berths to handle container short-sea, deep-sea and for inland shipping with having maximum draft 17 meter.

4.5.3 Case study-port of Long Beach

The Port of Long Beach is one of America's premier terminals and a pioneer in goods movement an environmental stewardship (POLP, 2011). Trade value is more than $140 billion moves annually and it makes it second busiest seaport in the United States. Besides, the port placed nearly 1.3 thousand hectares of land and it has 80 berths which perform with 71 post-Panamax gantry cranes. Top trading partners of the ports are China, Japan, South Korea, Taiwan, Vietnam, and Malaysia (WPS, 2011). Long Beach has seven main container terminals and their harbour draft is range from 8.8 to 15.2 meters but they have a plan to dredge by 17 meters.

Port of Long Beach's cargo container traffic in February jumped 10.9 percent a total of 458,336 containers and shortest link between Chicago and Shanghai is Long Beach port.

Figure 4.10 Long Beach Building New Piers

"We are building for the future" Dick Steinke, executive director of the Port of Long Beach said in a meeting and he continued about container volume and service of larger vessels and they will improve new structure to serve them. On the other hand, Los Angeles and Long Beach have dealt about the environmental issues surrounding growth. When they start dredging their harbour more than 50 feet and they will protect the environment form port operations.

Table 4.6 Port of Long Beach container capacity in 2011

Month (2011)	Loaded Inbound (TEU)	Loaded Outbound(TEU)	Empties (TEU)	Total Containers
January	242,445	127,546	104,969	474,960
February	233,660	121,929	102,747	458,36
March	191,211	131,761	89,263	412,235

The Long Beach Board of Harbour Commissioners has approved a $123 million dredging and building new berths it will be nest for ultimate size of containerships. In the first place, wharfs, dredging will be done and it is expected to finish next spring (POLB, 2011). If we compare March for 2011 and 2010, there is 2 percent decreased but according to the Port Authority these months are slower than others and it will be more than 10 percent risen end of the summer.

It is a fact that Long Beach Port will be more suitable for larger container vessel because they have invested huge amount of money and they have signed contract for environmental protection.

Table 4.7 Container capacity of long beach port in 2010

Months (2010)	Loaded Inbound	Loaded Outbound	Total Loaded	Empties	Total
January	217,925	113,183	331,108	97,697	428,805
February	207,920	123,208	331,128	82,006	413,134
March	206,652	130,495	337,147	85,627	422,774
April	241,245	130,155	371,400	113,659	485,059
May	264,505	138,659	403,164	121,551	524,715
June	262,053	116,112	378,165	141,935	520,100
July	293,878	126,177	420,055	167,826	587,881
August	311,240	126,039	437,279	173,723	611,002
September	288,905	124,021	412,926	161,864	574,790
October	303,168	150,581	453,749	159,872	613,621
November	274,480	142,628	417,108	141,199	558,307
December	256,889	141,140	398,029	125,282	523,311

5. MODELLING ULTIMATE SIZE OF CONTAINERSHIP

5.1 Empirical Results

The previous chapters have provided overall analyses of liner marketing volume and conditions. It is also mentioned that hub ports performance and major key factors play a big role on designing ultimate containership size. This chapter aims at establishing representative projection of ultimate vessel size which is optimized through the use of existing limitations.

The present document has established so far the possible determinants for current trade flows and supply of liner services among the certain routes for mega ships in order to be served. It is very important to point out the limitations and great emphasis currently to trade flows in the shipping marketing. After bringing key factors of ultimate size up for considerations, some important variables and evident conditions are changed to optimize better quality containership which is sufficiently qualified. It is also a matter that some big liner companies has agreements and deal to reach every part of world but building up ultimate size requires more Alliances because it is going to be much more volume and it must be distributed easily and quickly. This chapter mentions about technical details, limitations and, after summing up these circumstances, ultimate containership is going to be come out by optimization.

5.2 Container Marketing Trade Forecast

Shipping container marketing has been growing for nearly two decades and the market profile has been improving by new developments and strategies. However, the global container-shipping market has damaged by lower rates since overcapacity occurred where demand low. According to Reuters report (2011), containerized freight rates in Asia-European trade were recently trading about $978 per TEU; it went down from the more than 1,800 per container in July 2010. Moreover, container shipping companies have difficulty in finding new ways to handle fuel price fluctuation and they try to increase ship capacity in the process to maintain cargo levels.

“So you can understand why a lot of the shipping lines have moved towards adding additional ships in to reduce the amount of bunkers consumed. One of the problems that we are facing now in the industry is that terminal capacity is not keeping up with the growth in world trade, and in some cases you find that vessels have to queue and therefore are off schedule and required to speed to regain schedule” said John Lines, CEO of ANL Container Line. Even though John Lines gave negative approach to liner marketing in his speech, Maersk Company manager stand optimistic toward to negative progress. He highlighted some important points and problems of marketing in World Economic Forum and he continued “We are quite optimistic on the growth rate, we are talking 6 to 8 percent, but at the end of the year we may actually see it has been growing faster than that”.

According to Shipping Container Trader Sources in Europe, big liner shipping company stands like it seen below table.

Table 5.1 Top ten lists of liner shipping companies (SCT, 2011)

Company Name	Market share (%)	Total Capacity	Number of vessels	Ships order
AP Maersk	18	2,128,836	540	69
MSC	13.2	1,508,637	416	50
CMA CGM	8.6	1,033,486	366	60
Evergreen Line	5.4	594,154	162	20
APL	4	543,293	138	20
Hapag-Lloyd	3.5	472,804	119	14
COSCON	3.5	460,717	140	56
CSCL	3.4	460,717	140	17
NYK	3	410,185	108	20
Hanjin Shipping	2.5	409,363	92	30

On the other hand, one of the biggest problems for the marketing is financial crisis. Whenever they make future plans to invest large amount of money, sometimes stagnation comes out and companies have to cope with these. A study on container shipping market analysis was carried out by Dr. MeifengLuo (2008) and he put forward some major results about new orders. He indicated that industry profit motivates new buildings and industrial trade capacity plays a crucial role. As increase in marketing income bring up the number of orders and container freight designates industrial revenue. Forecast of new orders can be based on below factors:

- Total market size
- Market grown pattern
- Shipping market rate
- Positive forecast
- Industry size and volume
- Number of companies

In predicting the future container shipping marketing, several assumptions have been made to approximate future demand for container shipping performance to different scenarios on the future global trade.

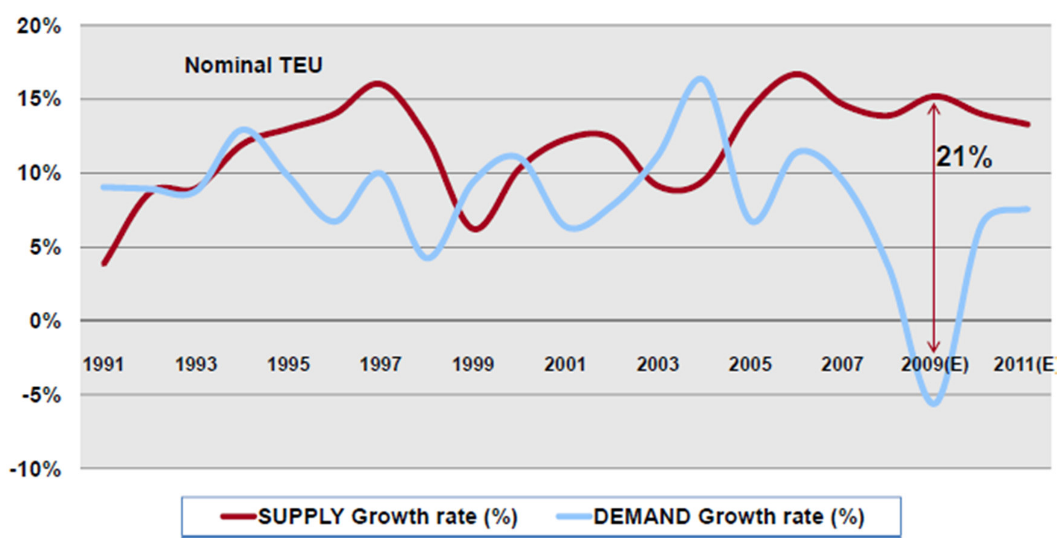


Figure 5.1 Supply and demand patterns (IHS, 2010)

In the whole world, based on IHS (2011) study, 182 containerships have over 10,000 TEU capacity and two companies share nearly 40 percent of them. Smaller vessels are squeezed because mega ships are more economic than the others. This idea has changed containerization marketing logic and companies have started signing contracts with hub ports.

Drewry Shipping Consultants reported (2010) in October that container shipping market will grow about 7 percent annually in the next five years as stability returns to industry. As a consequence, ultimate ship size can be very effective on liner marketing as long as fuel price fluctuation and freight rate problems occur.

5.3 International Rules and Regulations

Due to rapid development in the container market and big competition among the liner companies, the ship owners have been looking for larger vessel to increase profit. At the same time, earlier rules and requirements based one 350 meters but new rule is required to cover mega containership up to 450 meters. Several analyses are done to solve this problem (ABS, 2010):

- Non-liner sea load predictions
- Dynamic load approach
- Fatigue analysis
- Bow flare slamming analysis
- Springing analysis
- Whipping analysis
- Green water analysis
- Vibration analysis

On the one hand, position of the deck house is affected by ship's length in order to meet SOLAS requirement and in ultra large container ships the deck house has been moved near the midship. On the other hand, the containerships are more sensitive than the tanker and the bulk carriers, and open deck structure can be a source of problem due to movement in wave situation. Speed requirements, hull structure and length of ship are factors that make ultimate containerships sensitive to bow flare and stern slamming impact. It is reported by ABS that this can be achieved by the Large Amplitude Motion Program (LAMP) performed as a nonlinear hydrodynamic software program.

5.4 Limitations

As we design to ultimate containership size, the limitation must be taken into account. In the process of time, some obstacles can be taken up but "ultimate" ship is going to be designed according to certain existing conditions. Restriction of vessel on building up can be classified into five groups as they are shown below chart.

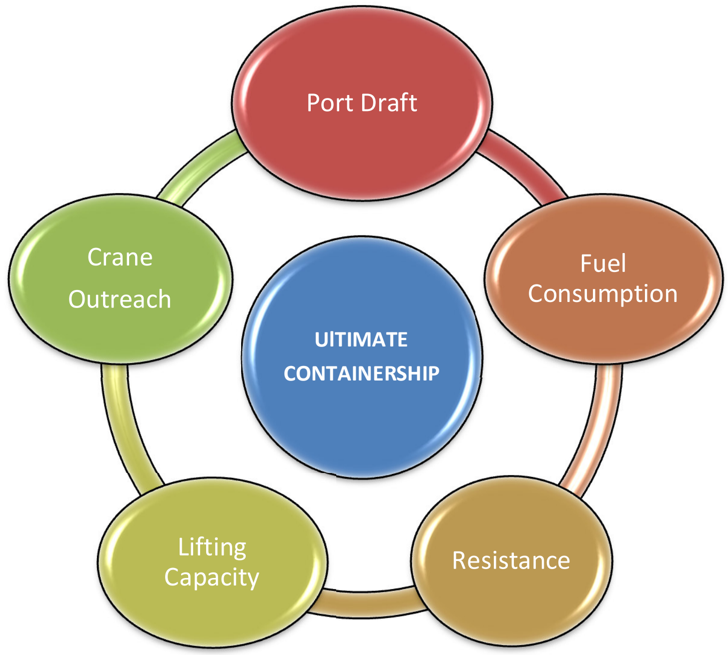


Figure 5.2 Limitations on designing ultimate containership

5.4.1 Port draft

For a long time, nobody had dreamed that mega ships which are over 350 meter could be designed. However, port and shipyard technologies have been developing and some they have changed and improved new point of view about shipping marketing. In the first place, the world's most important terminals were located North American (e.g. New York) and Western European (e.g. Rotterdam) but containerization marketing definitely changed and new location started to gain value because global trade increased more than demand. Besides, export oriented economic development took shape, Asian ports took the stage about handling container with high quality and building up mega vessels. One of the best things in China is having sufficiently qualified transshipment ports and the ports are acting as a door to open the World trade. According to statistic of Containerization International (2010), Singapore, Dubai, Los Angeles, Rotterdam, Long Beach, and Shanghai have been playing a big role on the global maritime transport system.

Table 5.2 Top list of hub container port (containerization yearbook, 2009)

Name of port	Country	Maximum draft
Singapore	Singapore	16.0
Hong Kong	People's Republic of China	15.5
Shanghai	People's Republic of China	15
Kaohsiung	Taiwan	15.2
Busan	South Korea	12.2
TanjungPelepas	Malaysia	14.8
Rotterdam	Netherlands	17.0
Dubai	United Arab Emirates	14.0
Hamburg	Germany	16.7
Antwerp	Belgium	15.3

As we are contemplating ultimate container ship about its dimension, one of the factors to clarify its draft is major ports berth' depth since it is going to sail between significant terminals. Containerization Yearbook pointed out ten busiest ports as it can be seen above table, depth of berths range from 12.2 meters to 17 meters. However, container ports authorities have been working on dredging seabed to serve larger ships and they will be able to handle containers of ultimate size vessels due to their future investment plan as it is given in chapter four. Ship owners changed their marketing strategies after global finance crisis occurred and it is noticed that large volume capacity ships are more effective than smaller one. All significant terminals order to be dredged over ultra large ships draft and the process has still been progressing by authorities so that they will manage to deal with ships within next five years.

Expansion Plan and New Panamax: Panama Canal Authority (2006) carried out a new plan to extend dimensions of Panama Canal and "Panamax" container size and classification refined according to expansion plan. Today, sustained increase in international trade and the consequent increase in the demand for passing through the Canal brought some new challenges and opportunities to use the waterway. After this expansion, the Panama Canal will manage to handle vessels of 13,000 TEU but even a third set of locks will be open to ships , however, Emma Maersk as well as many large tankers will not be able to pass since they are wider than Panama width.

Malaccamax Restrictions: The world currently being used is "Malaccamax" a ship limited only by the constraints of the Malacca Straits because containerships dimensions have been expanding. It is estimated that beam of nearly 60 meter and a length of 470 meter would have possibility to pass through this way. The mega container ship specification requires using Strait of Malacca since fuel consumption is the most important matter. It is also crucially required that "ultimate" ship is going to sail between particular ports such as Singapore Port and shortest way to go there is using this Strait. On the other hand, Henderson research showed that propulsion of mega ships could do with a single screw powered by an engine of 18 cylinder or twin screw arrangement can be two engines of 12 cylinders and 900 mm bore or two 7 cylinder versions of a new larger bore 1080 mm engine (Henderson, 2010).

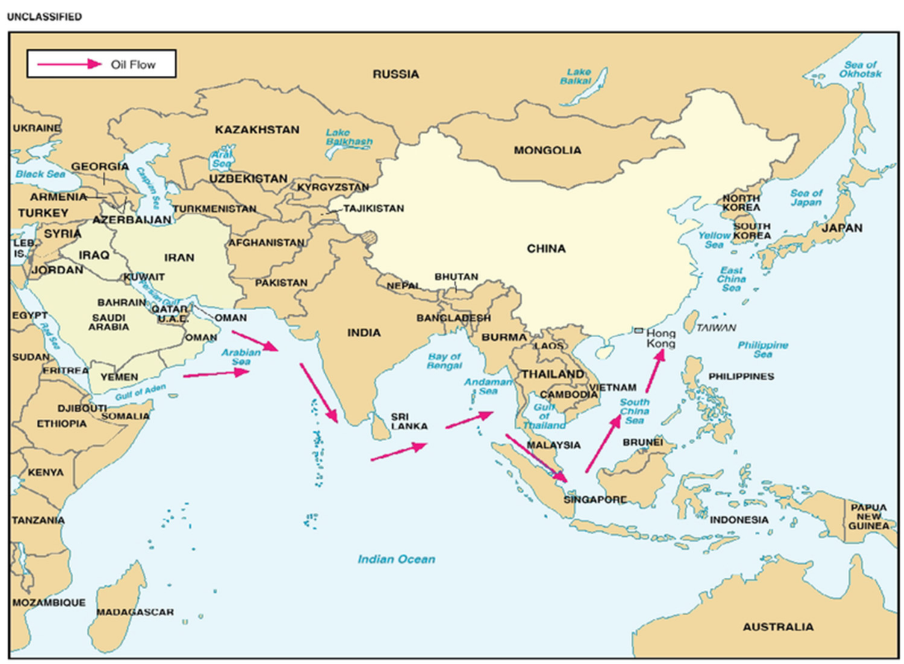
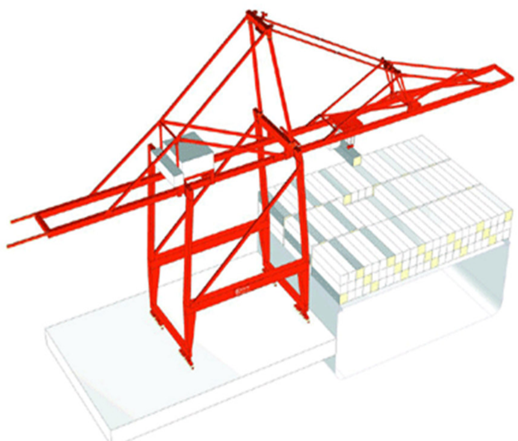


Figure 5.3 The strait of Malacca

As a consequence, ultimate ship size draft can be range between 14 to 17 meters it will depend on relation of other dimensions. Besides, Strait of Malacca has 25 meter depth and the ship propulsion and draft should be designed according to this limitations.

5.4.2 Crane outreach

Ship to shore gantry cranes are the workhorses of any high performance container handling equipment in the port because they have to be maintained 24 hours a day and 365 days a year. Before container marketing boom happened, types of cranes and their quality-service time were slower and poorer but their speed, capacity and outreach limit have been improving day by day by in cranes industry. Tsinker (2004) point out that new generations of cranes outreach limit extended over 60 meter having more lifting capacity are operational around the world. The high productivity of ship to shore cranes is due to major advances in crane technology, which includes use of twin-lift spreaders capable of handling 2 containers (20ft) and faster and it allows serving of mega containerships with high efficiency rate.



Capacity	40-120 tons
Outreach	30-70 meters
Rail-span	15-70 meter
Back-reach	0-25 meters

Figure 5.4 Ship to shore crane (Kalmar, 2011)

65 meter and 67 meter outreach are destined some major ports such as; Rotterdam, Malta, Los Angeles, Busan and Newport. Some crane companies invest big amount of money to build up new modification cranes such as; their rail-span, outreach, hoisting height as well as electrical installation to increase efficiency.

In a conclusion, ultimate ships size breadth can be between 50 to 70 meters but even if many hub ports' cranes outreach is 64 meter, their net-reach limit is 62 meter and the "ultimate" vessel's breadth is going to be 62m

5.4.3 Lifting capacity

The largest modern container cranes are classified as "Super-Post Panamax" which can handle about 22 rows wide. Some new cranes have now been built with capacity of 120 tons and they will be able to lift up four boxes (20ft). This type of cranes weighs nearly 1800 tons. Lots of container port authority would like to increase their volume and the best way they can do is having largest cranes to deploy stuffs very quickly. Number of Super Post Panamax order has been increasing about 6 years and at the same time capacity of vessels has been rising to get more profit.

To sum up, number of ultimate ships size container row is about 22 since the largest crane has certain capacity to deploy boxes.

5.4.4 Fuel consumption

Commercial interest now demands a close awareness of fuel consumption which is one of the major costs in vessel operation and shipping operator's attempts to decrease amount of consumption to improve economic performance (Motte, 1985). Main engines and vessel speed can determine fuel consumption so that it is designed and sailed particular way. In addition to this, container vessel travels at much higher velocity than a bulk carrier because loaded cargo must be delivered at a certain time but it will lead to a cubed increase in fuel consumption. Basically, container vessels are supposed to travel faster than the others since "just in time" is manner of work for liner shipping and fuel consumption takes a big part on costing of the vessel.

Table 5.3 Two different ships fuel consumption per day (Lloyd, 2009)

Knots	8100 TEU(tons)	13100 TEU(tons)
20	96.1	123.9
21	113.8	146.7
22	130.8	173.3
23	149.5	203.7
24	169.9	238.5
25	192.0	276.7

As it can be seen above Table, it is clear that the fuel bill increases very rapidly with speed and for 8,100 TEU vessel the decision to cut trading speed from 25 knots to 23 knots would result in a daily fuel saving over $30,000. The amount of fuel consumed by container ship is usually measured in kilograms of fuel per kW or per hours (kg/kW-h). Marine diesel requires advanced power system to obtain efficient power/weight ratio. Moreover, marine diesel fuel is more quality than bunker fuel which is cheaper so container ships burn dirty and such as asphalt fuel. The changing bunker fuel prices open the door for substantial cost saving by adjusting the sailing ships. One of the large ships may be running over \$100,000 bunker fuel per day and reducing cruising speed 20% can save nearly 50% of bunker oil. However, in order to maintain liner service frequency capacity and performance, decreasing velocity is not a good solution.

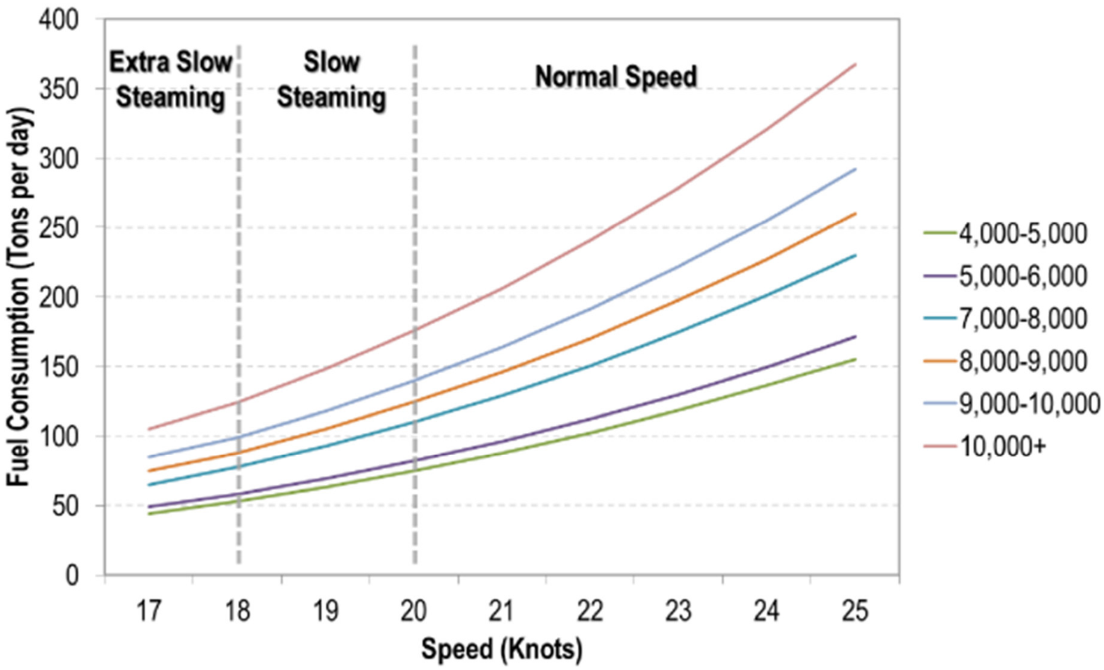


Figure 5.5 Fuel consumption of different vessel capacity (IAME, 2009)

Liner shipping companies have started to sail ships with different speed for various finance condition and it can be classified into four groups (IAME, 2009):

- **Normal** (20-25 knots): This speed performance represents the optimal cruising speed a containership and its engine have been designed to travel at this velocity but fuel consumption is higher than other conditions.
- **Slow steaming** (18-20 knots):to save from bunker cost it can be sufficient way but additional time is requested to sail over long distance.
- **Super slow steaming** (15-18 knots): this speed is also known as a commercial speed and main goal is decreasing oil consumption while ship maintains its service.
- **Minimal cost** (12-15 knots): even though this speed is commercially unacceptable, maritime shipping firms would adopt this type of speeds.

Containership of around 8,000 TEU would consume about 225 tons of bunker fuel per day at 24 knots but it could be nearly 150 tons each day at 21 knots but "ultimate" vessel will consume much more than other ships so its service speed can be nearly 24 knots to optimize expenditure.

5.4.5 Resistance

First of all, determining of vessel's resistance is one of the most difficult parts to find out suitable engine according to ship's hull. Additional resistance elements should be designed with regards to flow and efficiency of ship base on shape and alignment of propellers and rudders in the stern. Moreover, vessel's trim should be optimized for performance for each draft and speed to get better solution. In the study of Schneekluth, it is said that the shaped area can be covered protrusion possessing major flow factors and this method can be find certain resistance.

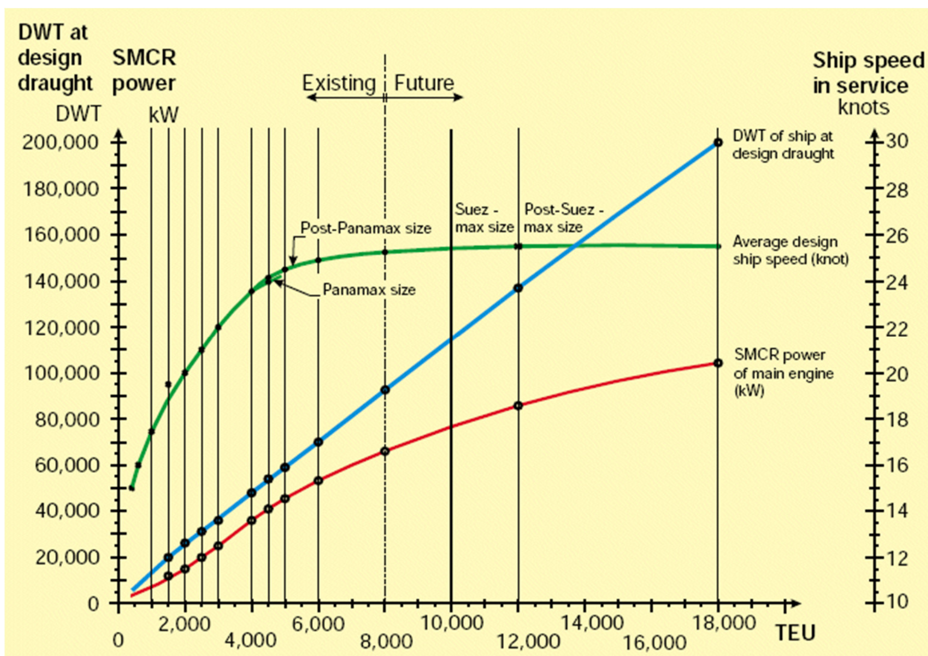


Figure 5.6 SMCR power and vessel volume

Even if we want to increase volume of the ship, power engines come up with resistance problems to get certain service speed. The containership is supposed to sail at medium or high speed so its wave-making resistance covers a major proportion of the total resistance. However, lowest wave-making resistance can be obtained by hull form optimization and Dawson and Rankine methods are generally used to calculate existing resistance.

In order to get hull form with the least resistance performance, optimization design model of minimum resistance is proposed based on the nonlinear wave resistance theory which is combined with CAD. Besides, I express "ultimate" model by scaling of the existing containership at Rhino program so that weights and measures allow obtaining enough form for calculations.

5.5 Transport Service

The box transportation by containership base on vessel's speed, cost per container and reliability. In transportation, potential profit depends on revenue from selling stuffs or services and they are related volume of transportation. To increase profit, there are two ways; increasing ship capacity and its speed but the speed can affect directly bunker costs and it is not economically sufficient way. Moreover, to increase round-trip frequency, the vessel's cruising speed and the cargo handling speed at the terminal should be adopted according to new generation (7^{th}) specifications. Based on economic theory, we can carry out profit model in liner shipping market as (Portfurio, 2006):

Table 5.4 Model of profit formula for liner shipping market

Π=R-C	Π=potential Profit, R=Total Revenue, C=Total Cost
R=Fr x Qf(Rf)	Fr=Freight Rate, Qt=Quantity Cargo Units (FEU)
C=Fc+Vcf(Rf)	Vc=Transportation Variable Cost, Rf=Round Trip Frequency
$\text{Rf=x} = \frac{\text{VQd}}{\text{Tt}}$	VQd=Vessel Operational Day Per Year, Tt=Round Trip Time

According to this above model formula, the most important major factor on shipping performance is round-trip frequency (Rf), since it affects both revenue and cost. Round trip frequency has also significant effects on transportation cost by achieving economies of scale or certain cost of larger number of cargo. Besides, for the purpose study of ultimate size containership, operational days are expected 330 days and rest of year days for vessel maintenance and repair. Portfurio indicated that the period of operational days divided by the Tt determines number of potential trips for vessel can succeed within a year. Tt is certain time for vessel between two terminals included; loading, unloading, and any other operational work, and can be defined as;

$$Tt = 2\left(\frac{D}{VS} + \frac{2(VCr \times Lr)}{Hr} \right) + \varepsilon$$

Tt=Round-trip period, D= distance between ports in nautical miles, VS= vessel speed in knots, VCr=vessel cargo-carrying capacity in FEU, Lr=Vessel load rate as percentage of Vc, Hr=cargo-handling rate for loading and unloading at the ports in FEU/hr, and ε= random productive time including pilotage, waiting time for loading/unloading.

Past research and literature have focused on increasing propulsion power to obtain more trips, however, increasing speed while maintaining the current port cargo-handling equipment and their performance is equivalent to “hurry up and wait” since existing port technologies may not able to reach enough speed to handle containers for mega ships except a few agile ports.

In a nutshell, to cope with ultimate containership operation there are two major items which should be considered; cargo handling rate in port and random productive time for the vessel because boarding time can be longer than other ships. Number of gantry cranes on “ultimate” vessel must be nearly six to be just in time performance.

5.6 Technical Details and Modelling

Mercator Transport Group (2005) announced major key containership design changes since 1985 and it is definitely clear from this report that key advances in the design of containerships which facilitated the rapid growth in size and efficiency of new generation vessels. Main changes and investments have been done on dimensions, propulsion and speed.

5.6.1 Structure

The most important aim designing ultimate size of containership is increasing capacity and having more space for boxes. In the first place, the capacity of containership is generally limited by vessel intact stability and increasing vessel below deck capacity can affect center of gravity and while it will be lower, ship capacity and effectiveness is going to be more advantageous. “The ultimate ship will carry half of cargo under the deck and container cell guide systems should be improved to save time. In the second place, the increased breadth of vessel will be able to carry more containers on-deck and the structure must allow the restraining force of the lashing assemblies to be done with effect angle. In other words, “ultimate” ship will be designed to carry more containers on-deck and its breadth will be 62 meter according to gantry cranes outreach capacity.

The ship hull is drawn by Rhino software program and then it is transferred to Maxsurf and Hydro-Max after that resistance results and technical details are carried out.

- The Ship Length (over-all)= 450m
- The Beam= 62m
- Draft=16.7m
- TEU design capacity= 21,000 TEU
- Displacement=432x62x16.7x0.71x1.025=325,517 tones,(water density:1.025gr/cm3)
- Deadweight=21,000 TEUx10.85 tons=227.850 tones (avg. container weight:10.85)

Figure 5.7 450m length form of container ship scaled by Rhino

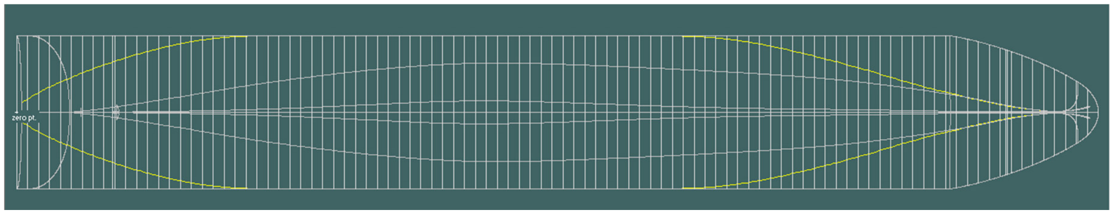


Figure 5.8 Form of ultimate size containership

According to determined limitation all necessary items are obtained by Max-surf program and form lines are shaped to calculate rough values for displacement.

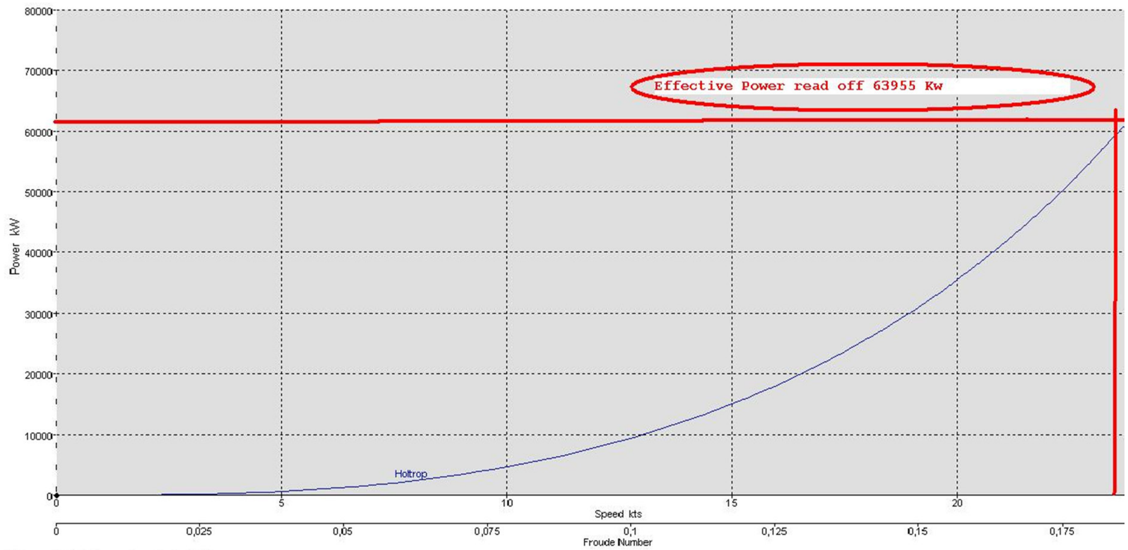


Figure 5.9 Resistance diagram of ultimate vessel according to speed

5.6.2 Main engines

Determination of optimum RPM, propeller and engine size are related to each other but the ship resistance has already found (attached to appendix part) and second stage is selecting engine according to necessary resistance and trust the formula is given below and appendix 5:

- ❖ The maximum propeller diameter behind the hull will be:

  $D_B = 0.6T = 0.6 \times 16.798 = 10.0788$ m

Open Water Diameter; $D_o = \dfrac{D_B}{0.95} = \dfrac{10.0788}{0.95} = 10.60926$

$P_{E\ (TRIAL)}$ is read-off for trial speed $V_{S\ (TRIAL)}$ =24 knots from P_E – V diagram (attached appendix 5)

$P_{E\ (TRIAL)}$ =103,339 KW at 24 knots but two engines are going to be used so 55,000 KW each engine will performance.

- Delivered Power:

$$P_D = \frac{P_{Etrial}}{\eta_D} = \frac{51669}{0.7} = 73812.85 \text{ KW}$$

$$N_{OPTIMUM} = 85.67$$

$$P_D = \frac{P_{Etrial}}{\eta_D} = \frac{51669}{0.72140630} = 71622.607 \text{ KW}$$

Therefore, $\Delta\ \eta_D < 0.005$, **η_D is 0.7200498 at 83 rpm.**

Engine selection: after modelling the ship via Rhino and getting results for the engine, we can put some details of the required engine size.

- $\eta_s = 0.98$
- $P_{B\ (TRIAL)} = \dfrac{P_{Etrial}}{\eta_D \times \eta_S} = \dfrac{51669}{0.7200498 \times 0.98} = 73221.976$ KW

$$P_{B\ (MCR)} = \frac{P_{Btrial}}{0.85} = \frac{73221.976}{0.85} = 86143.502 \text{ KW}$$

(This value can be used to find out how much space is required for engine.)

$P_D = P_{B\ (TRIAL)} \times 0.98 = 73221.976 \times 0.98 = 71757.536$ KW

	P_B (KW)	Number of Cylinders	P_B/ cyl
TRIAL	73221.976	7	10460.14
MCR	86143.502	7	**12306.21**

As it is seen above results, this type of machine is produced onto the order and MAN Company has appropriate engine for this power: two 7-cylinder HFO diesel engines rate at 55 MW each design speed nearly 24 knots.

5.6.3 Speed and propulsion system

As the size of mega containerships increased so has the some requirement for speed-powering system to maintain schedule to make them more effective on the transpacific route. Since 1985, the containership designed speed has increased from 23.0 knots to 26.0 knots but bunker cost still has a big problem (Mercator Transport

Group, 2005). To achieve the higher speed required, the container ship hull form has to be refined according to adaptation of main engine-propulsion system.

As we can see from figure of resistance-velocity (appendix figure A.2), optimum speed is 24 knots because after this limit too much power is required to move the vessel. Determination of ship propeller speeds in service is going to calculate according to below formulas and assumptions:

$P_{D=}$ 71757.536, Therefore, Assuming that $n_D = 0.7$

$P_E = P_D \cdot n_D$=(71757.536).0.7=50230,2752 kW

Now, using the table of P_E – Vs produced in step 1 the Vs for P_E = 50230.2752 kW is

Vs=24 knots

Service speed is 24 knots and two engines are accommodated to make it work. Two screw and 6 blades of propeller are used for ultimate size because it is aim to decrease bunker consumption with low speed.

Preliminary design of ultimate vessel: Weight estimation should be done based on empirical formulas for structure, machinery, auxiliary, outfit, and deadweight items where total weights equal to displacement.

$$\Delta=\Sigma \text{ Wi and } \Delta = \text{WLS} + \text{DWT}$$

$$\Delta= L * B * T * C_B * 1.025 = W_S + W_O + W_E + W_F + DWT$$

Table 5.5 Values of the ultimate vessel

Loa-length of the vessel	450m
L_{BP}-length of between perpendicular	432m
B-breadth	62m
V-speed	24 knot
R-diameter of the voyage	7662miles
C_B-block coefficient	0.71
T-draft	16.7m
D-deep	31m
P_B-two engines required	110,000Kw
BHP-main engine	149,600hp
BHP-auxiliary	47,600hp

Steel Weight (Ws): Watson and Gilfillan method is used for steel weight. As it is seen below, it is devised for the specific vessel, ultimate, and the constants is undoubtedly have been different but the availability of the data is formed according to the vehicle even if E(Lloyds equipment numeral) is over 15000.

$W_s \ = K.E^{1.36}$ and $\qquad E = L.(B+T) + 0.85L.(D-T) + 0.85\sum I_1.h_1 + 0.75\sum I_2.h_2$

For the containership K value is between 0.033 and 0.040 while E parameter ranges from 6000 to 15000ç

$0.85\sum I_1.h_1 + 0.75\sum I_2.h_2 \ is\ assumed\ 250$ and K is used as 0.036 so that we can find the vehicle steel weight.

E=39,499 **Ws=64219tons**

Engine and Auxiliary Weight (Ws): It is calculated according to Watson-Gilfillan method and main engine has 149,000 while auxiliary has 47,600 hp.

$W_M = \frac{BHP}{18} + 300$ **Wm=8611tons**

$W_A = 0.65.(BHP^{0.70})$ **Wa=1222tons**

Outfit Weight: Watson-Gilfillan method is taken for outfit weight which is composed by joiner bulkheads, hawse pipes, deck fittings, cargo booms, anchors, rudder, and gallery equipment.

$W_o = 0.45.L.B$ **Wo=12555tons**

Fuel Weight: It is necessary to hold certain amount of fuel at the tanks since the engine size is nearly 110,000 kW.

$W_F = P_S.F_R.R.\frac{1.016}{1000V}$ $\qquad F_R = 0.2265.P_S\ /(P_S\ - 855)$

$F_R = 0.2278$ **Wf=10715tons**

Each engine should supply nearly 55 MV and additional electricity may take up approximately 35 MV so all engine system is supposed to sufficiently qualify with 145 MV.

Table 5.6 The ultimate vessel weight

W_S-steel weight	64219 tons
$W_M + W_A$-engine and auxiliary weight	9833 tons
W_o-outfit weight	12555 tons
W_F-fuel	10715 tons

$\boldsymbol{W_{Light\,ship}}$**= 97322 tons**

Δ=Σ Wi and Δ = WLS + DWT

Δ=432x62x16.7x1.025x0.71=325,51 tons W_{LS}+DWT=227,850+97322=325,172tons

As we can see the results of the weights, displacement of the ship equals to total weight with approximately 325,000 tons.

Table 5.7 Some ships specifications

Ship Name	Loa (m)	Lbp (m)	B (m)	T (m)	DWT(t)	Disp(t)	Cb	Max TEU Capacity
CMA CGM MONT	365.6	348.20	48.4	15.5	142500	178125	0.67	16000
MSC DANIT	365.5	348.00	51.2	16	165517	206896	0.71	14000
CMA CGM M	365.5	348.00	51.2	15.5	157092	196365	0.69	13344
MSC FRANCESCA	363.57	346.40	45.6	15	131771	164714	0.68	11300
CMA CGM VELA	347.48	331.50	45.02	15.5	131831	164789	0.69	11040
CMA CGM TH	346.5	330.60	43.2	15	130700	163375	0.74	10960
Emma Maersk	400	381.20	59	14.5	165000	208000	0.62	15000
EVELYN MAERSK	397	378.40	56	15.5	156907	196134	0.58	13500
MSC LAUREN	366	349.20	48.4	15.5	139418	174273	0.65	12400
MSC LUCIANA	366	349.00	45.6	15.5	131463	164329	0.65	11660
MSC EINDHOVEN	366	349.00	48.2	15.5	140580	175725	0.66	13092
CMA CGM TITAN	366	349.00	45.6	15	131235	164044	0.67	11312
CMA CGM ATTILA	335	319.30	42.8	14.7	100400	125500	0.61	8530
MAERSK SEMA	332	316.60	43.2	14.5	107500	134375	0.66	8402
MSC LAURA	300	286.00	40	14.5	84920	106150	0.62	6750
Ultimate Size	**450**	**432.00**	**62**	**16.7**	**227850**	**325000**	**0.71**	**21000**

Case Study Modeling and Comparison: The Emma Maersk is one of the biggest ships in the world and she is powered by Wartsila –Sulzer 14RTFLEX96-C engine, currently the fleet's largest single diesel unit and it weighs nearly 2,300 tons with 109,000 horsepower equals to 82 MV. Her main engines burn approximately 14 tons of residual fuel per hour and it means 97,400 tons of fuel each year.

I will put some more expenditure details of Emma Maersk which has the biggest container volume in the world and then I will show differences between Ultimate ship and Emma Maersk.

Fuel Consumption (Sea-Port): It is accepted that the ship serves 330 days in a year and the ship is taken into the service for maintenance during the rest of the year. Emma's engine approximately consumes 15 tons per hour during its service way and it means 336 tons each day is required for it. Besides, the power is required to make auxiliaries work and they burn nearly 6.6 tons per hour and consumed of fuel goes to about 158 tons per day.

Moreover, one of the most important points is fuel consumption at the port since bigger vessel stay much more hours at port than the others. According to Maersk Company, Emma consumes about 32 tons per day at the port and the company gives importance to make handling in short time.

Table 5.8 Fuel consumption of two vessel

Ship name	Fuel consumption at sea	Fuel Consumption at port
Emma Maersk	494tons (158+336)	32tons
Ultimate Vessel	595tons (425+170)	41tons

The ultimate size ship is going to consume nearly 425 during the sailing and it must have 4 auxiliaries each one has nearly 10 MV and fuel consumption will goes up to 170 (estimated) tons per day. Moreover, it is guessed that the ship's engine will consume 41 tons per day at the port.

All items cost is calculated on per TEU and then real price will be shown according to number of TEU.

According to fuel consumption result per TEU, ultimate size vessel is more efficient than Emma Maersk with 0.030286 per TEU and it means it may save fuel up to 14%.

Port Charges: Port tariff is one of the major elements for liner shipping companies since vessels capacity are getting much more. It is a well-known fact that each port charges different price at different time even different days such as holidays. For example, Antwerp, as opposed to Rotterdam, port dues and rates lower than Rotterdam. An important issue to underline is the port dues and rates per container and Rotterdam port is more expensive for 2.24 Euros concerning the Emma Maersk (Arduino, 2010).

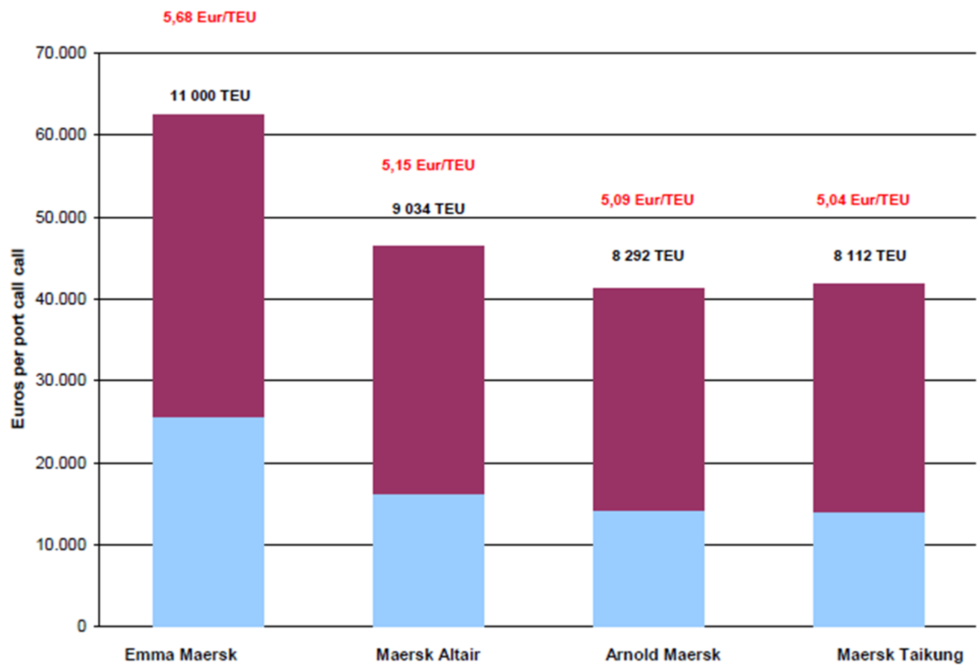


Figure 5.10 Container vessels' dues calling at Antwerp (Arduino, 2010)

According to above figure we can obtain a formula (per container) which is shown below and then we can calculate Ultimate Size Containership cost at the port for handling.

We can obtain the formula from the graph of Aurduino to compute handling cost such as $0,0002x + 3,2233$

It is very important that calculation is based on 80 percent cargo load per container. Handling Cost will be nearly 6.58 Euro/Container based on Antwerp port in Belgium while Emma Maersk port charge is 5.68.

Hire Base Cost: HB reflects the daily cost allocated to the fully manned ship whether in revenue-earning operation or not. The expense factors are crew and vessel expenses, and various overheads such as administrative, facility and equipment

HB=[Fixed Costs(ship expenses+crew expenses+ insurance+overhead)]/Operation Days

In addition to this, marginal income of a vessel per day is very important to make it profit. Even though liner marketing would get profit but freight rate and operation cost can affect them.

CB(Charter Base)= Variable Operation Costs/ Operation days

If CB is higher than HB, the operation will be profitable and this hypothesis examined that HB/CB decreases with increments of vessel size. Emma Maersk has 13 crews but there are two more officers necessary to make ultimate's engine work and it will be 15 people total crew of ultimate size. As it is said that the cost is based on per TEU so that Ultimate Ship has less expense for crew cost. Below table result are taken according to voyage included seven terminals. Service is started from Shanghai to Los Angeles Port and the fuel is loaded from Shanghai onto this scenario (653$ fuel/ton).

Table 5.9 Liner shipping cost elements for two vessels

1.Service Schedule	15000	21000
Distance of Round Ship	15328	15328
Service Frequency	Monthly	Monthly
Port calls on Round Voyage	7	7
Days at sea	27.5	26.5
Days in port	21.4	28.6
Total Voyage Time (days)	48.9	55.1
Voyage Per Annum	7.3	6.5
Outward Capacity Utilization	80%	80%
Return Capacity Utilization	90%	90%
Container Shipped Outward	12,000	16,800
Container Shipped back	13,500	18,900
Annual Transport Capacity	186,150	232,050
2.Ship Costs		
Operating Costs($/day)	8401	9729
Capital Value $mil	176.4	242.4
Depreciation Period years	20	20
Interest Rate	8%	8%
Capital Cost	59,504	78,880
Fuel Consumption (Tons/Day)	494	595
Bunker Price $/ton average	643	643

Bunker Cost $/day	317,642	382,585
Unit Cost Per TEU	21,17	18,21
3.Port Charges		
Port Cost /$ TEU	5.68	6.58
Port Cost /$ call	87,750*	110,600
4.Container Operations		
Twenty ft Containers(%ship capacity)	37%	%37
Forty ft Containers(%ship capacity)	57%	57%
Refrigerated Containers(%Ship cap.)	6%	6%
Number of Units on Full Vessel		
Container Repositioned empty(%)	10%	10%
5.Container Costs		
Container Cost(%/TEU/day) 20ft	0.9	0.9
Maintenance and Repair($/TEU/day)	80	80
Terminal Cost for Container Handling($/lift)	200	200
Trans-shipment ($/TEU)	225**	225**
Intermodal Transport Cost($/TEU)	150**	150**
Cargo Claims($/TEU/voyage)	25**	25**
6.Administration Cost		
Number of Employee Required	1158	1530
Cost/employee per annum	40,000**	40,000**
Administration Cost ($/TEU)	34.54	26.14

**Estimated according to Stopford (2010)methods

The service schedule described in Table 5.6 is based on the 15328 miles transpacific round voyage. According to my modeling, the ultimate size of containership will start from Shanghai, Kobe, Nagoya, Tokyo, Sendai, Oakland and it will end up at Los Angeles Port. Total voyage takes nearly 55.1 days for the ultimate vessel with spending 26.5 days at sea. Even longer ship sails nearly same days but number of hours at port could be different because of the capacity. Another important point is that the port has to be qualified at least four “super post-panamax” cranes to handle containers for just in time. Otherwise it will take longer and the profit will be lower but as it is seen chapter fourth that container ports are investing huge money to able to work for mega ships.

Table 5.10 Cash ($000)-flow modeling (Stopford, 2010)

1.Cost of the Ship on the Voyage	15000	21000
1.1 Operating Cost	231.02	257.8
1.2 Capital Cost	1636.36	2090.32
1.3 Bunker Cost	8735.15	10146.45
1.4 Port Cost	4756.12	6592.67
1.5 Total Ship Cost	15359	19086
2. Costs of Container on Voyage		
2.1 Cost of Supplying Containers	448.78	652.18
2.2 Cost of Container Maintenance	433.43	600.62
2.3 Total Container Cost	882.21	1252.80
2.4 Container Cost of % Total Cost		
3. Administration Cost		
3.1 Administrative Cost Per Voyage	1036	1108
3.2 % Total Cost	10%	10%
4. Cargo Handling		
4.1 Terminal Cost for Handling	2145	3003
4.2 Total Cost for Handling	10447	12470
4.2 Handling and Onward Transport, % Total Cost		
5. Voyage Cost		
5.1 Total Voyage Cost	27721	33916
5.2 Cost Per Teu Eastbound	1040	938
5.3 Cost Per Teu Westbound	1465	1380*
5.4 Average Cost Per TEU	1252	1159
5.5 %Change in Average Cost	-	-7.42%
6. Voyage Revenue($000)		
6.1 Freight Rate per eastbound leg	1750	1750
6.2 Freight Rate per TEU westbound	750	750
6.2 Total Revenue	28124	39373
7.Voyage Profit($000)		
Voyage Profit(loss)	11069	16109
% TOTAL REVENUE	**39.35%**	**40.9%**

TEU capacity	**1200**	**2600**	**4300**	**6500**	**8500**	**11000**	**15000**	**21000**
%Revenue	10%	24%	29%	32%	35%	37%	39.3%	**40.9%**

- As it is seen from table 5.7, ultimate size of containership is the most profitable with 40.9%.
- Emma Maersk was built up in 2006 and it costs 145million dollar and it makes approximately 11million dollar profit within a round trip.
- Investment cost of the vessel is estimated nearly 210million dollar and it will have almost 6 round-trip between the ports with over 16 million dollar profit on each voyage
- Working period is calculated 330 days and rest of the year is for maintenance
- There is really big fuel price differences between Asia and America and the way from Asia will be more profitable
- If we consider liner marketing conditions, ultimate size will save and protect the companies because it will struggle fuel price and freight rate per TEU which is changed every time.
- More containers means less CO_2 emitted per box and it will have energy efficient and it will make its economy of scale attractive
- Number of crew is 15 officers, if we concern per TEU cost it will be less than the others.
- Consumed fuel per container is less than all other vessel (0.03028)
- The vessel can carry almost 46,000 more TEU than Emma Maersk in a year and it will have less port calls.

5.7 Markups

On the basis of dimensional consideration the optimum "ultimate" size of containership will be configured as follows:

- Overall capacity 21,000 TEU
- Maximum LOA around 450m
- Ship breadth 62m because of crane outreach capacity
- Maximum draft 16.7m
- Design speed between 21-25 knots depending upon powering considerations
- Above deck 23 rows
- Thereof below deck capacity= 10,750TEU
- Thereof above deck capacity=10,250TEU
- Displacement at summer draft is calculated 325,000 tons at 16.7 m.

Bunker cost is one of the biggest problems and the ship is sailed with slow speed to be more efficient such as 24knots (nearly 450 MT/d). The above allows an estimation of scale economies to be developed. Moreover, as the deckhouse moves forward the container capacity increases, as a result of the visibility requirements, superstructure is located at about mid-ship. It also provides a few benefits such as spare space under this superstructure for fuel tanks or auxiliary machine. The issue of optimum vessel speed and the question of twin or single screw have been found to be an important factor in cost estimation so the propeller diameter is about 10 meters and slow speed engine program is useful for ultimate size vessel. In order to decrease cavitations ratio of propeller, determining number of blades is crucially important and using four or six blades screw is suitable for low speed.

It is very important that mega containerships have some difficulty when they are docked or approached to port's berth since length of the vessel is over 350 and their maneuverability are more sensitive than other ships. According to IMO maneuverability criteria and major hub ports berth, "ultimate" vessel size is designated 450 meter to operate conventional steering system. Even if it is going to be hard to manage the vessel in port area, with adequate power and tug assistance, access will be possible for the vessel the significant European, Asian and hub ports. Besides, gantry cranes investment always runs ahead of ship capacity and all new terminals have been investing for "super post-Panamax" cranes for several years. As it is mentioned before, major hub ports have invested huge amount of money for future plans such as; dredging berth and having modern equipment with railway system. "The ultimate" vessel breadth is designed 62 meter because the biggest crane is an outreach of 64 meter but net-reach is 62 meter. The ship draft is 16.7 meter with full-loaded condition and there are two container terminals can handle this type of vessel cargos but the other big ports will have up to 17 meter depth within 5 years. We have undertaken a major review of crane and yard productivity in the light of planned technical improvements and further acceleration in handling rates. Some technical solution can offer the capability to develop port efficiency and at least 6 gantry cranes should be performed on "the ultimate" vessel to improve productivity.

To sum up, timing the introduction of 7th generation (the ultimate) of vessel is very difficult and the vessel will only be employed on the Asia-Europe, Transpacific and major trades.

5.8 Summary

Driven by the economy of scale for ever more efficient container transportation system, the size of largest container vessel is expected to increase over the next few years. The commercial studies performed in the past and construction orders evidently submitted that there are much more benefits of transporting containers on larger ships.It is reported in October that container shipping market will grow approximately 7 percent annually in the next five years as stability returns to industry (Drewry, 2010). In addition, International rules and Regulations for mega containerships are changed due to their dimensions and some new rules are carried out by authority to consolidate the structure and loaded condition. Limitations on designing "ultimate" vessel are brought such as; port draft, lifting capacity, resistance, fuel consumption, and crane outreach. According to those obstacles 7^{th} generation vessel is designed and some major hub ports are clarified to be performed by the vessel with certain route. Technical details and engine requirement are calculated for particular service speed, 24 knots, and two engines are accommodated with 6 blades of screw to decrease bunker consumption. Finally, superstructure is located nearly mid-ship and fuel tank is placed under the structure to have more space for containers and then the vessel capacity is determined with 21,000TEU.

It is a fact that there is some important side-effect of "ultimate" size ship and they can be classified:

- Engine power and engine accommodation
- Propulsion system selection; single or twin screw
- Hull design: generation of high quality lines since there would be longitudinal strength problems and resistance
- Propeller design: number of blade, efficiency, diameter, and adaptation with main engine
- Propeller cavitation erosion and hull vibration
- Maneuverability of vessel and stopping performance
- Stability
- Ports infrastructure; berth depth, crane capacity and its speed

If above factor can be done clearly, the "ultimate" vessel will be economically benefit (oil-price and bunker cost) for global trade.

Although there are so many advantages of building up ultimate size containership, there will be some penalties such as:

- A much higher capital commitment
- Reduced flexibility and employment
- Slower port turnaround-although these should be minimized by using 6 gantry cranes.

6. CONCLUSION AND RECOMMANDATIONS

6.1 Summary

The literature on the economies of scale reveals one thing: using larger volume vessel is achieved only when the vessel's space is fully loaded. When ship's volume is not fully utilized and the volume demand is only just as good as filling up a small capacity, then using smaller volume ship is better option in terms of overall cost efficiency. In the light of the foregoing information, the assumption is made in this research setting that the ship under study is designed to be 100% utilized.

Other than economics of scale, the major on the factors designing "the ultimate" containership carries out some key points:

The study included the following targets:

- According to shipping industry authority, liner shipping marketing volume is going to increase 7% next five years and some new investment is required to handle it.
- Fuel prices have been fluctuated since 2001 and servicing small size of ships are not efficient anymore so larger vessel have been built up to obtain more advantages.
- Finance crisis carried out major co-operation such as; new conferences and alliances and they allow shipping companies chartering the vessel together.
- The trade between America and Asia has been rising and transpacific route is more appropriate for "ultimate" size of containership.
- It is also targeted for mega ship, dimensions of the vessel is not going to be problem to pass through the USA and Asia route. Otherwise, Panama Canal and the other strait are not suitable for this type of vessel.
- Numbers of goods exported from Asia to America and America to Europe have been increasing and ships started to carry more boxes to be more economical.

- The competition between liner shipping companies has been heating and they can just play on price of TEU expenditure except fuel consumption. The new trend is having larger volume of ships to obtain lower cost and compete with the others.
- Shipping lines, such as APL and Evergreen, are increasing the number of ships in their fleet of 10,000 TEUs or greater. Maersk Line, for instance, is currently the most aggressive player in the mega-containerships market and they have ordered 18,000 TEU capacity vessels to Daewoo Shipyard.
- Even though we want to build up the biggest vessel, there are some limitations such as; port draft, handling equipment, engine size, bunker prices, resistance, and propeller system.
- The ultimate size designing aim is to be sailed between hub ports and there are significant terminals to cope with huge amount of boxes and supplying sufficiently enough services.
- The vessel breadth is determined according to “super post-panamax” gantry crane outreach capacity but 21,000 TEU capacity vessel is required at least 6 cranes to be just in time.
- The main routes are chosen from Asia (Singapore-Shanghai) to America (Los Angeles-Long Beach) and between America to Rotterdam or Hamburg way are suitable because trend of trade patterns is more positive within those ways.
- To get more benefits from 7^{th} generation vessel, key factors on determining the vessel details are worked out and some necessary requirements and investments are offered.
- One of the most important decisions on designing the vessel is determining the most efficient speed and engine-propeller adoptions. Some ship resistance calculations are computed and then service speed is made a decision at 24 knots with twin screw.
- The more ports a vessel calls on results higher the cost per TEU, interestingly, forming a mega vessel shuttle between two different markets can reduce cost per TEU.
- On the other hand, the vessel will incorporate MAN diesel engines that more than meet the environmental protection regulation of the IMO because it will consume less fuel and achieve nearly 25% reduction of emissions.

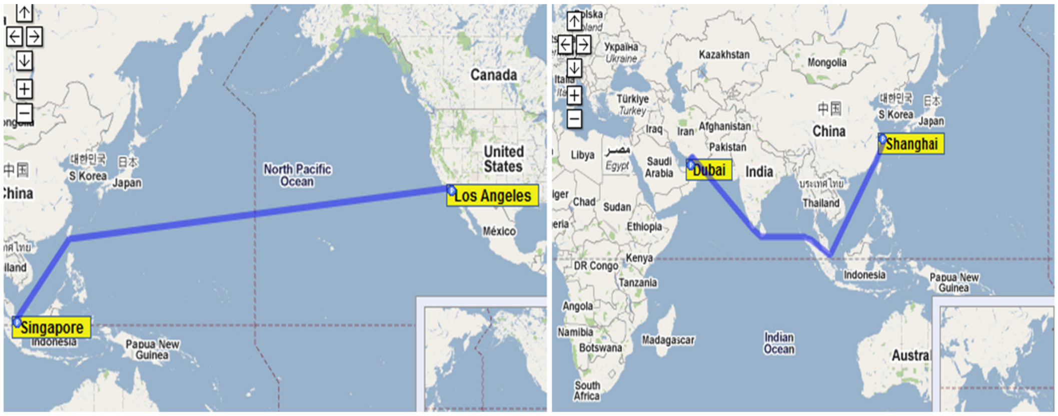
- As a consequence, the vessel capacity is carried out 21,000 TEU and if we compare to smaller ships (5,000TEU) there are so many advantages using this ships. Besides, maintenance and operation cost for smaller ships can be problems for liner shipping companies but “ultimate” vessel is designed to be serviced 330 days in a year, otherwise, it will have difficulty in being more profitable.

The research results show that shipping companies have undergone changes in recent years, especially dramatic change in a key market segment of China, changes in the regulatory nature of the marketing, and a number of alliances have been increasing to cope with competition and obtain more profit. Larger ships have economic scale when at sea since cost per TEU transported declines as the ship size increases. In order to control total costs of operating a large containership, they try to operate shorten the time in port and maximize the time at the sea. Besides, “the ultimate” vessel has some demand to be sufficient such as; the main route (shuttle), port selection (handling time and berth draft), and the schedules. These findings are made according to existing marketing conditions and its planning is going to be hard for these circumstances. At present, international demand for larger containerships movements are forecast to remain strong while bunker cost is one of the biggest problems.

6.2 Comparison

For shipping activities, bunker fuel is considerable expense. Fuel prices have risen dramatically in the last five years and it directly affects the freight rate on designing service speed. Operational cost per TEU depends on volume of vessel and there are some important factors can increase daily cost of the mega ships such as; insurance, lubricating cost, crew expense, port operational cost and maintenance cost.

Table 6.1 Main routes for ultimate size container vessel



From Singapore Port to Los Angeles Port:

- 7662 nautical miles
- 15 days 5 hours at 21 knots service speed
- Fuel consumption: 6,645 MT
- Post-panamax gantry crane can handle 65 tons and can lift two containers at a time.
- Bunker price per ton at Singapore: 643$
- Bunker price per ton at LA: 657$ (Clarkson, 15 May 2011)

From Shanghai Port to Dubai:

- 5571 nautical miles
- 11 days 1 hours at 21 knots service speed
- Fuel consumption: 4,873 MT
- Fuel cost per ton at Shanghai: 640$
- Fuel cost per ton at Dubai: 649$ (Clarkson, 15 May 2011).

As it is seen clearly, bunker cost increase from Asia to Europe and it will affect the freight rate since there is certain difference between fuel oil price. When the ship may sail between the west-east ports, most probably freight rate will change nearly 10% and it brings some more details to make the business work.

Table 6.2 Daily vessel operating costs by vessel size

Nominal TEu	Eff. TEU Capacity	DWT (mt)	Speed	Fuel cons. At sea	Fuel cons. In port	Daily cost (estimated)*	Acquisition cost($mil)
1,000	840	14,000	18,0	38	3	26,527	53.10
2,000	1,800	30,000	21.5	52	5	36,879	116.80
3,000	2,700	40,000	22.0	92	9	65,347	196.46
4,500	3,900	60,000	24.0	160	13	111,931	254.22
6,000	5,400	81,000	25.0	246	16	169,514	328.32
8,000	7,200	100,000	25.0	386	20	262,682	365.18
10,000	9,600	120,000	25.0	307	24	214,157	452.58
12,000	11,800	150,000	25.0	342	28	239,390	545.30
14,000	13,800	175,000	25.0	375	32	263,329	601.16
18,000	17,300	210,000	25.0	415	38	293,091	672.98
21,000	**20,250**	**230,000**	**25.0**	**445**	**41**	**314,442**	**741.00**

Source: Herbert Engineering Corp. / Mercator Transport Group

6.3 Recommendations

This research could be improved in several directions. Determination of demand side can be developed by using actual direct cargo movement, laden and empty container, within South Asia and West America. A historical data of such information will supply more forecast accuracy. However, it is always difficult to get all existing information to be used. In the first place, port planning could be done more suitable for the vessel; handing equipment, railway-system to hinterland, and infrastructure of terminal can be improved according to the ship's condition. In the second place, main engine accommodation and its size can be improved to have more space and it can be also more efficient way because fuel consumption can be decrease at the same service speed. Existing marketing conditions have some limitations to build up over 450 meter ships, technical obstacles and demand on container marketing can be studied for developing the vessel performance. Therefore, it is strongly expected to research about key factors of designing mega-ships. Although ultimate size of containership have so many advantages due to having more space, but it brings a few major problems which should be solved:

- Longitudinal tension problems and fatigue analysis
- Modeling and analysis for piping and electric system
- Lines plans of hull and superstructure
- Propeller system and rudder stuffs problems

Another area of importance for further research is to examine in details the level of service provided in terms of transit time and port stay. One of the biggest gaps waiting to be improved is service speed limit since vessel can spend less time at sea to increase number of service.

REFERENCES

Acciaro, M. (2004). Private Sector Financing of Container Terminal Infrastructure. MSc Thesis, Erasmus University, Netherland.

Almec Corporation, (2002). Final Report for ASEAN Maritime Transport Development Study. Japan.

Anton, V., (2010). Economic Feasibility of the Northern Sea Route Container Shipping Development-Logistic and Transport.

ABS, (2010). ABS Refines Rules for Large Containerships. Houston, USA.

Branch, A. E, (2007). Elements of Shipping. Eighth Edition, Routledge, New York, USA.

Bettina V., (2008). Operating Cost 2008; A Study on the Operating Costs of German Container Ships, Berlin-Germany.

Benini, F. (2006). Consolidation in Container Liner Shipping-Merger Control Aspects, Competition Policy Newsletter, 1025, 1, pp. 84-88.

Bdp1 Consultant, (2007). Infrastructure Investments. Connecticut, USA.

Bomba, S. M. and Harrison, R. (2001). Planning for Mega containerships: Statewide Transportation Planning Approach, Journal of Transportation Research Record, Vol. 1777, no. 1, pp. 129-137.

Chan C. T. and Lee H. H. (2000). *Containers, Containerships & Quay Cranes: A practical guide*. First Edition, Singapore: Gensis Typesetting & Publication Services.

CMA CGM-LORTHIOIS G., (2008). *Container Shipping: Impact of Mega-Containerships on Port in Europe*. Mareforum.

Cudahy, J. B. (2004). The Containership Revolution. 'Malcom McLean's 1956 Goes Global'. TR News September, p. 46.

Cullinane, K. P. B. and Khanna, M. (1999). 'Economies of scale in large containerships'. *Journal of Transport Economics and Policy*, Vol.33, No 2, pp 185-208.

Deveci, A. (2003). Personal Communication, University of Izmir, Turkey.

ECLAC, (1998). Concentration in Liner Shipping. First Edition, United Nation Publication, Miami, FL.

Ekin, N. (2009). *Container Trade in Turkey and Designing Hub Port in Mersin*. Thesis, Istanbul Technical University, Turkey.

Freightwise, 2006. *Freight Market Structure and Requirements for Intermodal Shifts*. Newcastle University, UK

Fuentes, P. and Vouvillion, W. (2006). The Economics of Increasing Speed in Sea Transportation: The Case For The Southern U.S., Mexico, Central America and the Caribbean, Journal of Food Distribution, 35, 01, pp 93-98.

Germanischer Lloyd, (2005). Trends in Development of Container Vessels.Athens, Greece.

Global Insight, (2009). Responding to the challenges-Assessing the Options, Containerization International Post-Conference Workshop, London.

Hapag-Lloyd, (2005, October). Lloyd Container Line. Latest Trends in Container Shipping, Basel, Switzerland.

Hernandez, L C. (2006). Intraregional Trade and Liner Shipping Services in The Association of Caribbean States. MSc Thesis, Erasmus Rotterdam University, Netherland.

Hutchinson M. J. (1982).-An Estimate of Operating Costs for Bulk, Ro-ro and Container Ships. 2nd Edition, Australian Government Publishing Service-Canberra.

Hwang, C. C. H., (2005). 'Analysis of Hub Port Choice for Container Trunk Lines in East Asia': Journal of the eastern Asia society for transportation studies, vol.6, No:2, pp 907-919.

Ircha, M C. (2001). Serving Tomorrow's Mega-Size Container Ships: The Canadian Solution, International Journal of Maritime Economics, Vol.3, 2001, pp.318-332.

Kee, K Y J. (2006)-Optimum Container Ship Size for Intra South Asia Services. PhD Thesis, Erasmus University Rotterdam, Nederland.

Kendall, P M H, (1972). 'A theory of optimum ship size': Journal of transport economics an policy, vol.1, No:2, pp 128-146.

Kim K. K, (2007).Container Terminals and Cargo Systems. First Edition, Springer, Berlin-Germany.

Luo M. (2011).Container Shipping Market Analysis and Prediction. Report, Internal Control and Management, China.

MAN B&W Diesel, (2004). Propulsion Trend in Container Vessels. Copenhagen B &W publications, Denmark.

Marcus, H. S, (1987).Maritime Transportation Management. Print Edition, Routledge, Massachusetts, USA.

Mercator Transport Group, 2005. Forecast of Container Vessel Specifications and Port Calls within San Pedro Bay. Bellevue, WA.

McConville, J. (1999). Economics of Maritime Transport: Theory and Practice. First Edition, Witherby, London.

Motte, R. and Laurence, C. A. (1985). Fuel Consumption in Container Ships on the North Atlantic. Journal of Navigation, 38, pp 258-265

Panama Canal Authority, 2006. Proposal for the Expansion of the Panama Canal-Third Set of Locks Project. Miami, USA.

Pierre, C. (2008). Liner Shipping Strategies: an overview. First Edition, World Maritime University, Sweden

Pozdnakova, A. (2008). Liner Shipping and EU Competition Law. First Edition, Kluwer Law International, Netherland

Rogan, M. (2006). Maritime Policy and Management. First Edition, Routledge, New York, USA.

Schneekluth, H. and Bertram, V. (1998). Ship Design for Efficiency and Economy. Second Edition, Butterworth Heinemann, Oxford

Stopford, M. (2009). Maritime Economics. Third Edition, Routledge, New York, USA.

Tongzon, J. (1995). Determinants of port performance and efficiency, Transportation Research Part A: Policy and Practice, Volume 29, Issue 3, 245-252.

Tsinker, G. (2004). Port Engineering-Planning, Construction, Maintenance, and Security. First Edition, Hoboken, New Jersey

UNESCAP, 2007. Regional Shipping and Port Development Strategies. New York, USA.

Vulvovic, R. (1999). Industry-Driven Changes and Policy Response Washington, Changing Ship Technology and Port Infrastructure Implications, pp 59-64.

Yang, C. H. (2001). Impact of Bigger Vessels on Shipping & Ports. Report, Shipping-Logistics and Port Research Center, Korea Maritime Industry.

Zhang J and Xu J.H. (1999). Impact of Large Vessels on Shipping and Ports. Report, China Scientist Institue, China.Bonney J, (2010). Cargo Theft by Gangs Increased in 2010, http://www.joc.com/ logistics-economy/cargo-theft-gangs-increased-2010, 29 April 2011

Energy Oil News. (n.d.). In Reuters. Date retrieved: 08.05.2011, adress: http://http://af.reuters.com/article

Url-1 <http:// www.mccaughrinmaritime.com>, date retrieved 29.06.2006.

Url-2 <http:// www2.nykline.com/liner/container >, date retrieved 10.01.2007.

Rutkoski, R., (2009). Mega Container Ships Add To Shipping. Journal of Bibliographic Research, 5, 117-123. Date retrieved: 13.04.2011, adress: http://www.supplyexcellence.com

Conradsen, S., (2009). Mega Container Ships Add To Shipping. Journal of Bibliographic Research, 5, 117-123. Date retrieved: 13.04.2011, adress: http://www.supplyexcellence.com http://jbr.org/articles.html

Zaja D., Zamarin A. and Hadjina, M. (2009). ongitudinal strength of a container ship. Date retrieved: 13.04.2011, adress: http://hrcak.srce.hr/index.php

APPENDICES

APPENDIX A: Form of the ship

APPENDIX B: Relation of speed and resistance

APPENDIX C: Perspective views

APPENDIX A

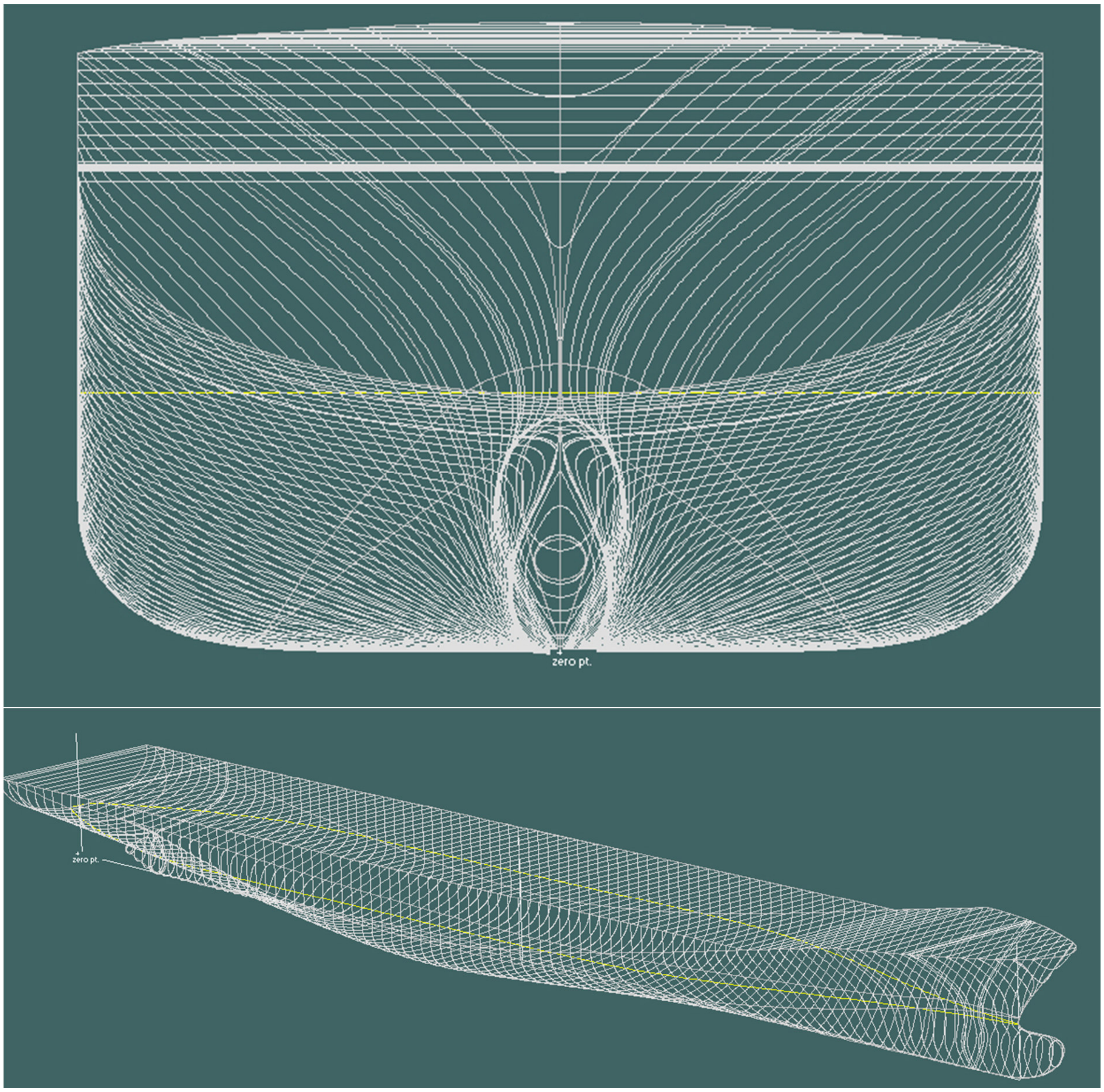


Figure A.1-Ultimate size of containership's form by Rhino

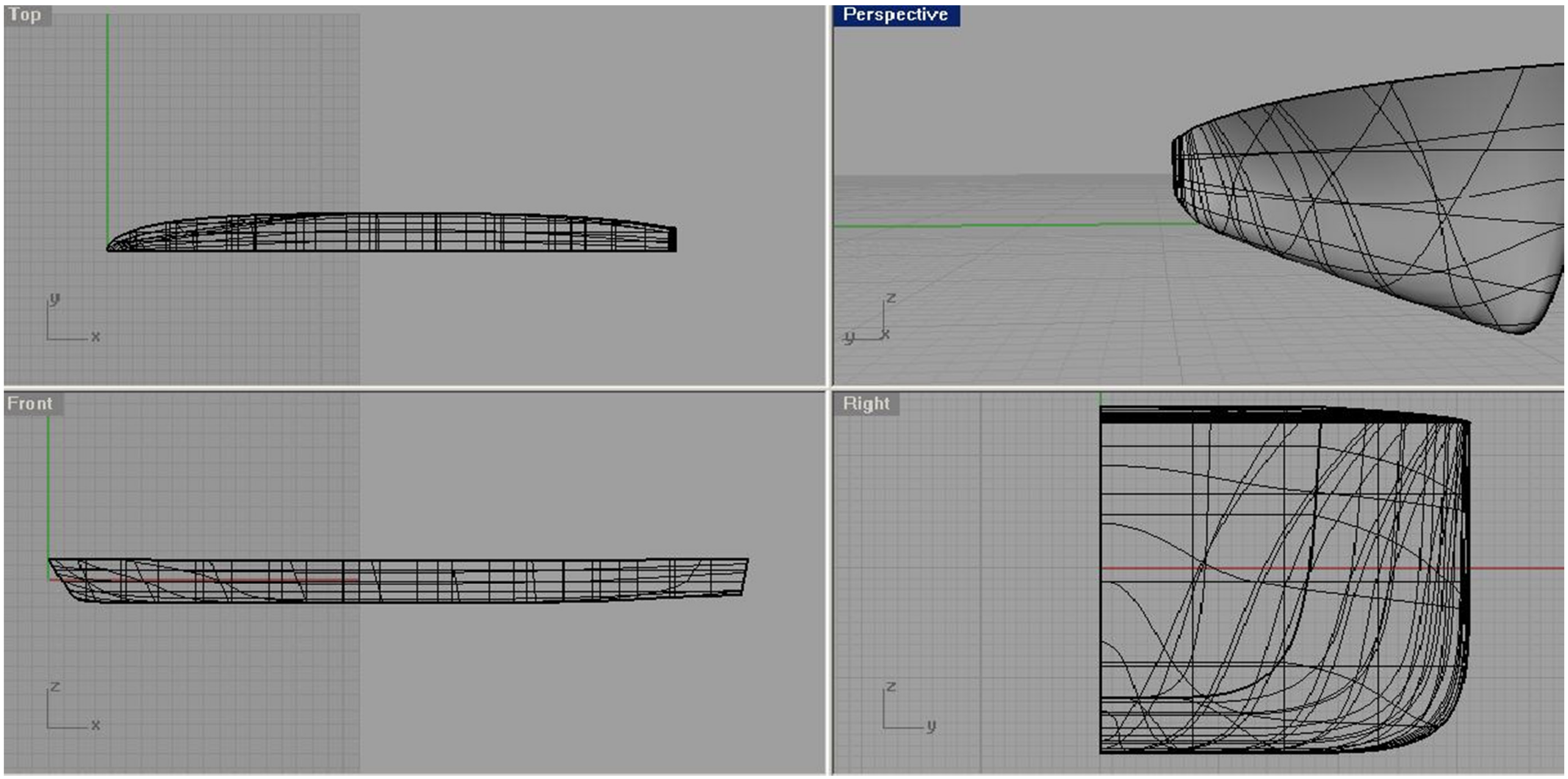
APPENDIX B

Table B.1: Resitance-speed correlation

Speed(knt)	Resistance(KN)	Power(kW)
9,75	731,65	4317,43
10,4	826,64	5203,21
11,05	927,14	6200,53
11,7	1033,14	7315,86
12,35	1144,66	8555,85
13	1261,75	9927,4
13,65	1384,49	11437,79
14,3	1513,01	13094,79
14,95	1647,5	14906,83
15,6	1788,17	16883,16
16,25	1935,33	19033,94
16,9	2089,33	21370,44
17,55	2250,58	23905,18
18,2	2419,57	26651,99
18,85	2596,84	29626,16
19,5	2782,97	32844,49
20,15	2978,62	36325,38
20,8	3184,49	40088,79
21,45	3401,31	44156,35
22,1	3629,85	48551,31
22,75	3870,91	53298,37
23,4	4125,27	58423,6
24,05	**4393,82**	**63955,41**
24,7	4677,51	69924,77

APPENDIX C

Figure C.1: Ultimate vessel perspective views



1. CURRICULUM VITAE

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Address: Merkez Mahallesi 3.Sokak No:19 Bagcilar/ISTANBUL

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B.Sc.: Naval Architecture

Professional Experience and Rewards:

Lear Corporation — Turkey (working) 09/11 to -/-

Product Engineer, 09/11 to -/-

Appointed to Product Engineer position of Lear Corporation to design wire and harness assemblies of Ford Motor Company projects. Depends on the harness design of projects and feedback from customer, he made the engineering, improvement, documenting, development and affirmation of the products and communicated with the engineers of the customer in order to achieve feasible designs. Besides, he has followed up all technical knowledge which can affect harness design and its sub-factors, so he has brought him skills with automotive industry.

Meke Marine — Turkey 09/08 to 06/09

Naval Architect, 09/08 to 06/09

Working as a Sales Engineer brought me unique experience because I had chances to make presentation and meeting different people. Besides, analyzing the marketing and getting results improved my skills and finding the way to expand my company profit based on relationship will always be my milestone for getting new vision.

Rewards:

- Graduated 2^{nd} ranking at ITU
- Name shown four times through honor degree list
- Student of Erasmus-2010/2011 at University of Newcastle Upon Tyne
- 13 Championship of bowling