Quest Journals
Journal of Software Engineering and Simulation
Volume 9 ~ Issue 7 (2023) pp: 48-61
ISSN(Online) :2321-3795 ISSN (Print):2321-3809
www.questjournals.org

Research Paper

Tale of Container Ship

Hossain K A, PhD
Hossain KA, PhD is a professor/researcher/Examiner both in MIST and in BUET, Dhaka, Bangladesh.

Abstract. *The International Shipping Industry has state that, about 90%, of the global trade in goods. Again, according to the International Chamber of Shipping, at present there are more than 50,000 merchant ships operating in the oceans of the globe. Container ships are now the largest and successful commercial seaborne vessels and the competitor of crude oil tanker or giant bulk carrier. More than 90% of non-bulk cargo worldwide is transported by container ships. Container ship capacity is measured in TEU. Usually loads are a mix of 20-foot (single TEU) and 40-foot (two TEU) ISO standard containers. Statistically around 80% of the world's containers are either twenty- or forty-foot standard length boxes of the dry freight design. These well-known containers are rectangular closed box designs and made of corrugated weathering steel with doors installed at one end. Today MSC Irina has become the world's largest container ship, with a capacity of 24,346 TEUs. It was put into service in 2023 and is sailing under the Liberian Flag. The giant containership is about 400 meters in length and moulded width of about 61.3 meters. This short-reviewed article will briefly describe the evolution of the container ship history, types, operation, and safety, including state of designing, building and ending of their life as scrapped.*

Key Words. *Container, TEU, intermodal containers, ULCS, Feeder Ship, freight*

***R**eceived 14 July, 2023; **R**evised 25 July, 2023; **A**ccepted 28 July, 2023 © The author(s) 2023.*
P**ublished with open access at **www.questjournals.org

I. Introduction

Today in the world of trade the shipping industry holds a significant role for transportation of cargo in all forms. International shipping is fulfilling around 90% of the movement of commodities worldwide. According to figures from the International Chamber of Shipping, there are currently more than 50000 different types of merchant ships operating in this industry, moving various sorts of cargos on a daily basis. These ships include cargo ships, bulk carriers, tankers, LNG, LPG, and container ships. In reality, the availability of more containership in the current marine freight industry has significantly altered the pattern of global trade during the past few decades [1].Container ships are special type of the cargo ships that carry box type load in truck or lorry size intermodal containers, in a technique called containerization. They are a typical type of commercial intermodal freight transportation and currently transport the majority of seagoing non-bulk goods. An intermodal container is a large standardized shipping container that designed and built for intermodal freight transport. These containers can be utilized for ship, rail, or truck transportation without the need to unload and reload their cargo. Thus, containerization greatly reduced the expense of international trade and increased its speed, especially of consumer goods and commodities [8]. Additionally, it significantly altered the nature of port cities globally. Today container ship is known as the workhorses of a global economy. Due to the increase in world trade the ship operator's pursuit for greater economy and has resulted in a massive increase in the size of container even ultra large container ships over the last decade. Around 60% of the cost savings of the most recent vessels are related to reduce service speeds and more efficient engines not scale. These mega ships can impose significant costs on port infrastructure. The earning power of these mega ships also significantly depends upon the extent to which they are being filled.

Over the past few years, we have seen megamax container vessels in the size range from 18,000 to 24,000 TEU and have become the 'standard' ship on many East - West mainlines, and they presently dominate the liner trade between the Far East and Europe. Today, there are 139 of these ships in service and another 50 on new ship order, slated for delivery within the next few years. Today, Alphaliner will be looking at the 'gigamax' a hypothetical container ship of up to 28,880 TEU, and weigh the pros and cons of such a design [92]. So, the ever increasing size of contain ships is a common thread in the main trends that have emerged in the container shipping industry over the past decade: gigantism, the decoupling between trade and fleet expansion, and the unpredictability of volumes, an oversupply of vessels and market attentiveness, among others [93]. On the other

hand, container ship accidents and lose of container at heavy seas can contaminate the surrounding marine environment and even have wider impact. It was found that, the number of container ship accidents and container lose incidents at sea have significantly increased in the past decade, and most accidents and incidents occurred in ports, harbors, piers, anchorages, berths, and open seas. The risk of marine pollution from container ship accidents is complex due to the variety of containerized cargo [90]. This reviewed article will briefly describe the evolution of the container ship from history, categories, classification, design concept, construction, safety, pollution, including state of starting and ending of those ships' life. This paper is mainly based on secondary data and information.

Container and Containerization

Intermodal containers have been primarily used to store and transport materials and products efficiently and securely around the globe. These containers are known different names; container, freight container, ISO container, shipping or sea container or container van or box, sea can. Intermodal containers are in many types and a number of standardized sizes [18]. However, 90% of the global container fleet is dry freight or general-purpose containers. Those are durable, corrugated steel boxes and are usually 20- or 40-feet standard length [8]. Well known standard ISO shipping containers are 8ft wide, 8.5ft high and come in two lengths; 20ft and 40ft. Special extra tall shipping containers called high cube containers are available with 9.5ft high. On the other hand, containerization is a system of intermodal freight transport using intermodal containers. Those containers' dimensions are uniform. These containers are versatile and can be stacked, loaded and unloaded, conveniently transported over long distances, and switched from one means of transportation to another without needing to be opened. The containers handling system are completely mechanized, so that all handling is done with cranes and special forklift trucks. Such containers are numbered and tracked using computerized automated systems.

Advantages of Containerization

The advent of containers not only transformed shipping but also completely altered international trade. In comparison to days for a traditional cargo ship, a container ship can load and unload cargo in a matter of hours. Ultimately, besides reducing labor costs, has reduced shipping times between ports to a great extent. Containerization has also resulted in less breakage due to less handling as well as less danger of cargo shifting during a voyage [9]. Pilferage and theft levels have been greatly reduced as containers are sealed and only opened at the destination. Containerization has lowered shipping expense and it has in turn helped the growth of international trade. In modern times, freight that once arrived in cartons, boxes, bales, barrels, or bags usually comes in factory-sealed containers with no visible indication of their contents other from a product code that machines can scan and computers can track. This system of tracking has been so correct that achieved almost zero error. Today, owner of the goods of containers can track his/her things by tracking and finding that particular container at any time, whether it is onboard ship or in any port.

History

Containerization has successes a revolution in the world of shipping. But its introduction did not have an easy passage. Ports, railway, road and shippers were concerned about the huge costs of developing the ports, railway and road infrastructure needed to handle container ships, and for the movement of containers on land by rail and road. Trade unions were worried about massive job loss among port and dock workers at ports. It took ten years of legal battles before container ships would be pressed into international service [9]. Containerization originated several centuries ago. The first ships made to transport uniform load units were used in England in the late 18th century. The box boat Starvationer, designed by James Brindley once more in 1766 to transport coal from Worsley Delph to Manchester via the Bridgewater Canal, features ten wooden compartments. Before the WW II first container ships were used to carrying baggage of the luxury passenger train from London to Paris. These containers were loaded in London or Paris and carried to ports, Dover or Calais, on flat cars in the UK and CIWL in France. However, it was not well developed or widely applied until after Second World War (WW II) when it dramatically reduced the costs of transport, supported the post war boom in global trade as well as globalization. The first purpose-built container vessels began operating in Denmark and between Seattle and Alaska in 1951 [10]. The Ideal X, a T2 tanker, carried 58 metal containers on its inaugural journey between Newark, New Jersey, and Houston, Texas, becoming the first commercially viable container ship. Due to the requirement for warehousing and the manual sorting of the majority of shipments, containerization has grown in popularity. Ultimately it displaced many thousands of dock workers who formerly handled break bulk cargo [59]. At the same time, it has reduced congestion in ports, significantly shortened shipping time and has minimized losses from damage and theft. Container ship safety is under the spotlight with ever-increasing ship sizes, as evidenced by the January 2015 inauguration of the world's largest container ship, the MSC Oscar (19,224 TEU).

Recently, Mar 2023, the China State Shipbuilding Corporation has delivered its MSC Tessa megaship to the Mediterranean Shipping Company. With a deck area of about four football fields, it's capable of loading up to 24,116 TEU containers at a time, stacked up to 26 deep [94]. As of today, MSC Irina and MSC Loreto are the largest ships (more specifically containerships) in the world in terms of DWT and cargo capacity. These massive ships have a tonnage exceeding 240,000 DWT and can carry up to 24,346 TEU of cargo. Nn addition, the new design allows for containers to be stacked up to 25 layers high, and that providing greater capacity for cargo transport. These ultra-large container ships (ULCS) are the same length as others in their class; and are considered the biggest is because their deck arrangements provide for their 24,346 TEU container capacity [95]. Interestingly, container ships aren't like supertankers, which can deliver their cargo through a big liquid-transfer hose. Again, dock facilities tend to place the upper size limits on machines like the MSC Tessa, and the current limits are likely to remain as big as these things can get until a useful number of ports worldwide build out the land infrastructure to deal with something bigger. So as total tonnage and container capacity creeps up, it's largely a matter of optimizing the ships' design to squeeze more and more on board. Particularly which makes it impressive to see that in last decade since the Maersk Triple-E reigned supreme with its 18,000 TEU container capacity, and shipbuilders have managed to expand capacity by a hair under 34%. So, containers caring capacity is remain as race to innovate and develop bigger ships.

Design and Construction

Today the hull of a cargo ship is a complex arrangement of steel plates and strengthening beams. Ship's hull is built around the keel. Bordering on ribs and fastened at right angles to the keel are the ship's frames [5]. The metal plate work that covers the top of the hull frame work is supported by beams and that are attached to the tops of the frames and run the full breadth of the ship is the ship's main deck. The beams are support the deck as well as along with the deck, frames, stiffeners and transverse bulkheads, strengthen and reinforce the shell and hull. Today the hulls of a ship is a set of double bottom tanks, which provide a second watertight shell that runs most of the length of a ship. Normally a ship's engine room accommodates its main engines, shaft assembly, generator, pumps and auxiliary machinery. The engine room of a modern and large ship is located in the aft part of the ship [18].There are few key points in the design of modern container ships. Similar to bulk carriers and conventional cargo ships, container ship hulls are constructed around a robust keel. With this frame is set one or more below deck cargo hold, several tanks and the propulsion plant room. Container ship's holds are usually topped by hatch covers and where more containers can be stacked. Growth of container ships (size and carring capacity in TEU) in last 50 years has been shown in figure 1 below [91].

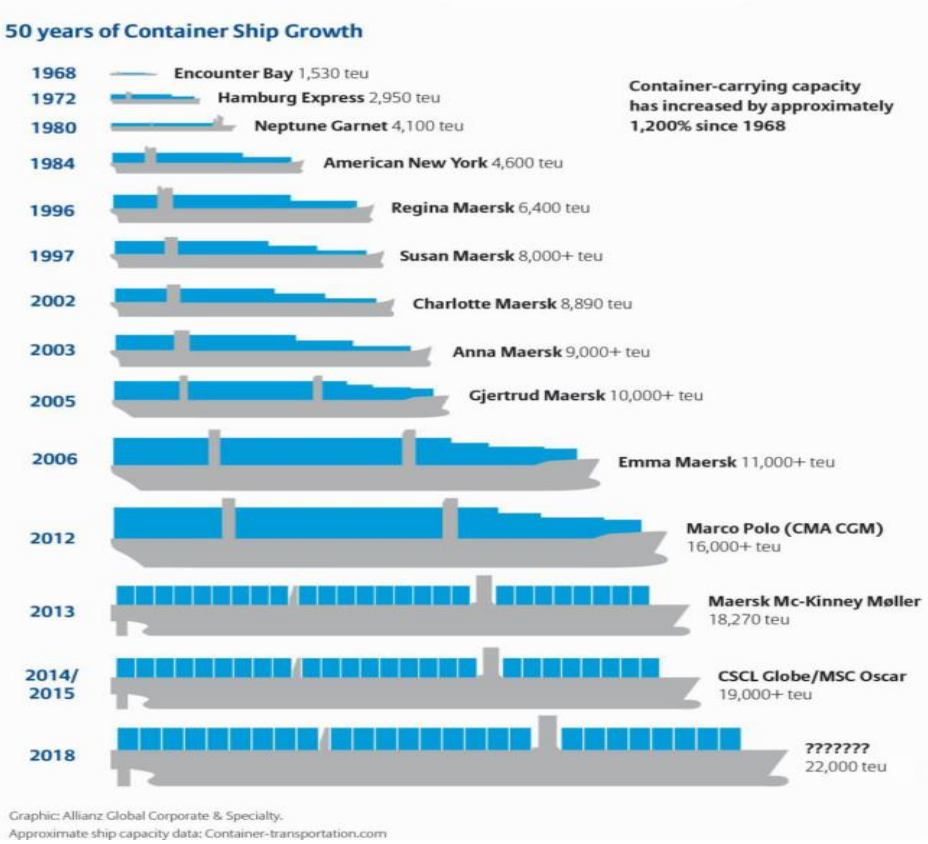


Figure 1: History and growth of container ships in last 50 years [91].

There is cargo cranes placed aboard vintage container ships. Modern some have specialized systems for securing containers on board. Actually efficiency is another key factor to design of container ships. Specially designed cargo holds are used on dedicated container ships to speed up loading and unloading and effectively secure containers while at sea. Another key aspect of container ship specialization is the design of the hatches; the openings from the main deck to the cargo hold. The hatch openings stretch the entire breadth of the cargo holds, and are surrounded by a raised steel structure or hatch coaming and top of the hatch coamings are the hatch covers. Modern hatch covers of container ship are articulated mechanisms that are opened and closed using powerful hydraulic rams. One of the key components of dedicated container ship design is the use of Cell guides and those are strong vertical structures constructed of metal installed into a ship's cargo holds. During loading, these unique features direct containers into clearly defined rows and offer some support for containers against the ship's rocking at sea. Three dimensional systems are used for cargo plan to describe the position of a container on board ship. First dimension or coordinate is the bay; which starts at the front of the ship and increases towards aft. Second coordinate is tier; the first tier at the bottom of the cargo holds and number increases towards top [13]. The rows is the third dimension or coordinate; the rows closest to the centerline are given low values, and the rows farthest from the centerline are given higher numbers. Starboard side is assigned an odd number and port side is assigned an even number [66]. Basic design concept of a container ship has been shown in figure 2 below [33]. Arrangement and loading of containers in holds and above hatch of a typical container ship has been shown in figure 3 below [96].

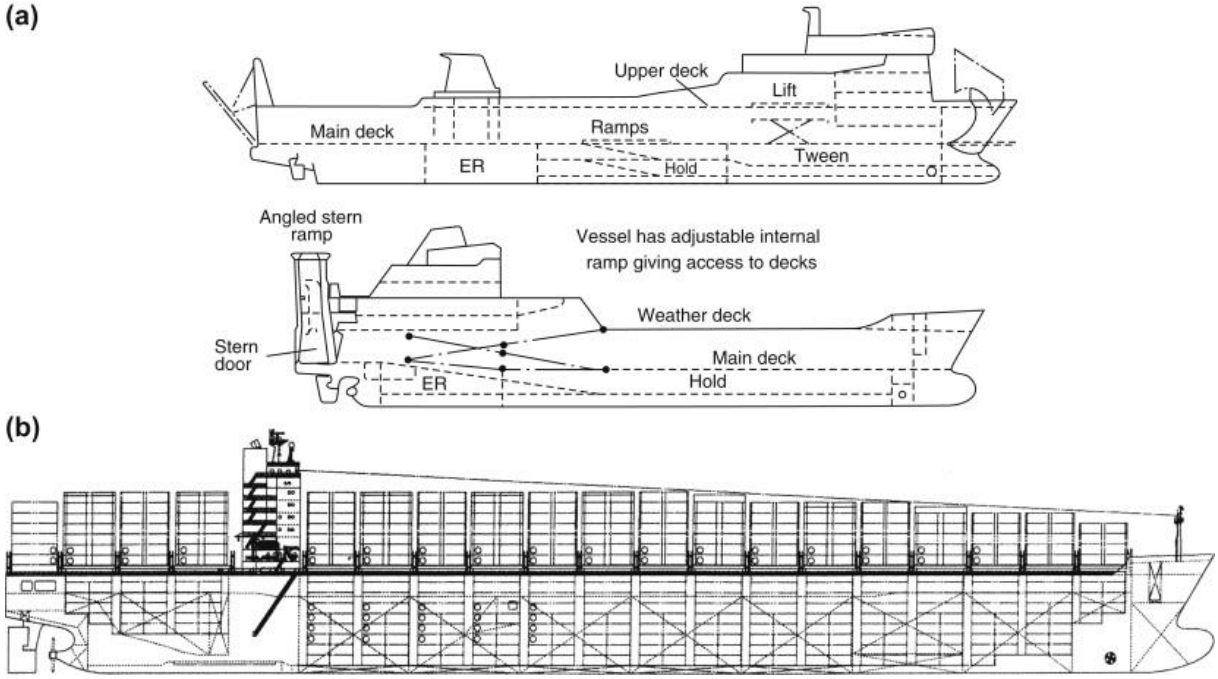


Figure 2: Basic design concept of container chip [33]

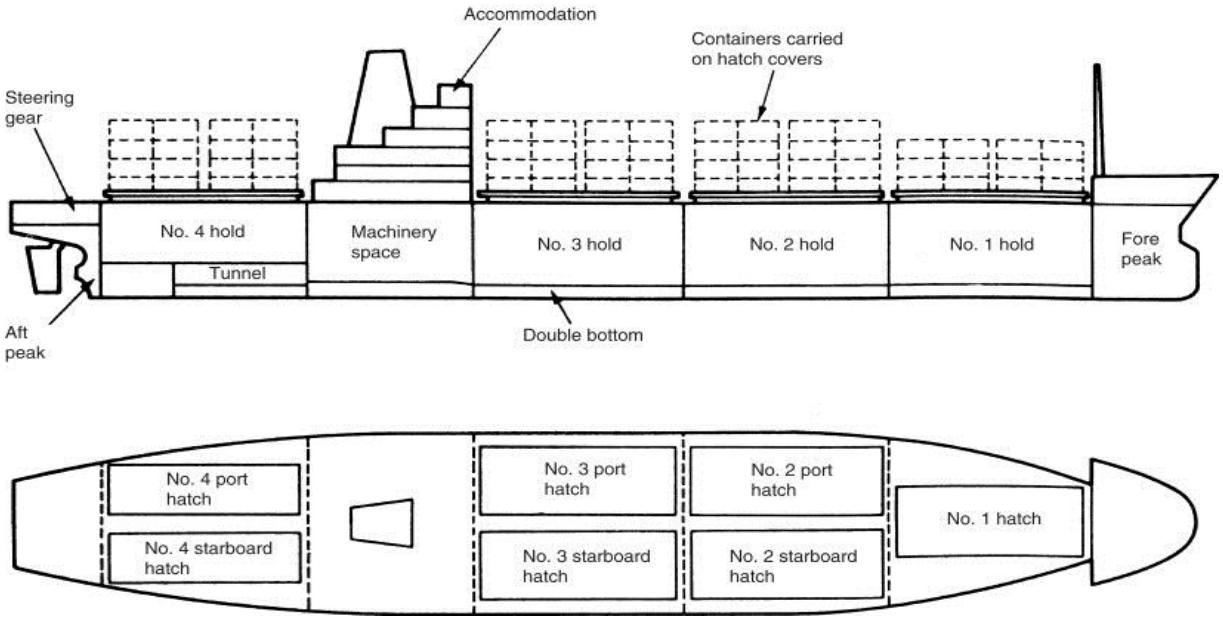


Fig 3: Arrangement and loading of containers in hold and above hatch of a typical container ship [96]

Type and Class of Container Ships

The definition of a containership class is a function of draft and related capacity in TEU. Since the beginning of containerization in the mid-1950s, containerships undertook six general waves of changes, each representing new generations of containerships [72].The container ship becoming bigger day by day. There are larger ship designs on the drawing boards [74], such as the 'Malacca Max' class, that could carry about 27,000-30,000 TEU, but they are not expected to be constructed until there are sufficient volumes on the limited routes these ships could service. Each subsequent generation of containership faces a shrinking number of harbors able to handle them and places pressure on port infrastructure and equipment. Maritime shipping companies are incited to use the largest containerships possible on their shipping routes since they benefit from economies of scale. However, ports and inland transportation systems must provide substantial capital investment if they expect to accommodate larger containerships. Thus, operational limitations are to deploy ships bigger than 8,000 TEU in terms of ports of call and the required infrastructure to provide an acceptable loading and unloading throughput [75]. If we consider the evaluation of container ship, it may be classified as shown in below. Comparision of Panamax and Post-Panamax container ship dimension has been shown in figure 4 below [71]

- **MGX 24:** Very recent past an additional expansion in 2019 introduced ships of 24 containers across and with 24 bays, dubbed Megamax-24 (MGX-24).Those ships have a capacity of 21000 to 25000 TEU. These ships are very gigantic and too large for any canals. The ULCS/Megamax-24 is getting close to the technical limits that the Suez Canal can accommodate, beyond which the commercial relevance declines substantially. Routes and ports Megamax ships can service are more limited, mostly to routes between Asia and Europe and potentially some transatlantic routes.

- **Ultra large container ship (ULCS):** The extension of the post-Panamax design led to the introduction of the Ultra Large Containership class of 18,000 TEUs and above in 2013 (named 'Triple E' by Maersk). This class was further expanded, and by 2017, ships above 20,000 TEUs started to be delivered. These ships are very large for any canals. Today capacity of ULCS is 18000 to 21000 TEU. Maersk, MSC, UASC, CMA CGM, and China Shipping have launch their 18000+ TEU capacity ULCS [59, 67].

- **Very Large Containership (VLCS):** By 2006, the third generation of post-Panamax containerships came online when Maersk shipping line introduced a ship class with a capacity in the range of 11,000 to 14,500 TEUs; the Emma Maersk (E Class) [73]. The vessels in this class have 397 meters in length, a width of 56 meters, and a deadweight of 156,907 tons. For this impressive size, only a crew of 13 is required. Depending on the load configuration, its capacity is in the range of 12,000 to 13,500 TEU, which can be accommodated in rows of 22 containers wide. A problem related to this class of containership concerns its draft of 17.5 meters (57 feet), limiting the number of port terminals it can call to, placing this ship in the Post Panamax category. The number of ports capable of handling VLCS is limited, particularly

ports in river deltas that can face access channel constraints. This refers to ships designed to fit exactly in the locks of the expanded Panama Canal, which opened in June 2016.

- **Post Panamax:** By 1996, full-fledged Post-Panamax containerships were introduced, with capacities reaching 6,600 TEUs. The first Post-Panamax ship classes were not much longer than the Panamax class, but wider, making them more efficient. A ship above the Panamax size requires a substantial amount of cargo to be used profitably along a service loop. By the late 1990s, the rapid growth of global trade made such a ship class a marketable proposition. Those ships are too large to transit the current Panama Canal and undertake trans-ocean voyages. Their size is typically 5500–8000 TEU though larger ships with over 10,000 TEU capacities have been built so far [68].

- **New Panamax:** These ships have a capacity of about 12,500 TEU, but there are several configurations of Neo-Panamax ships in terms of length and width. Those ships including most Post-Panamax ships would be able to transit the expanded Panama Canal. Those can carry up to around 12,000 TEU [69].

- **Panamax ships:** During the 1980s, economies of scale rapidly pushed for the construction of larger containerships. As we know that, the larger the number of containers being carried, the lower the costs per TEU. The size limit of the Panama Canal, which came to be known as the Panamax standard, was achieved in 1985 with a capacity of about 4,000 TEUs [76]. Those ships can transit the current Panama Canal and can carry between 3000 and 5000 TEU.

- **First generation** of containerships: The first generation of containerships was composed of modified bulk vessels or tankers that could transport up to 1,000 TEUs. The first containership, the 'Ideal-X' was a converted World War II T2 tanker [77]. These ships were carrying onboard cranes since most port terminals were not equipped to handle containers. They were also relatively slow, with speeds of about 18 to 20 knots, and could only carry containers on the converted decks.

- **Feeder ships:** Those ships are smaller vessels that do not undertake oceanic voyages but are generally engaged in shipping containers. The smallest of these may only carry several hundred TEU [71]. Actually there is no specific subclass below Panamax size [59].

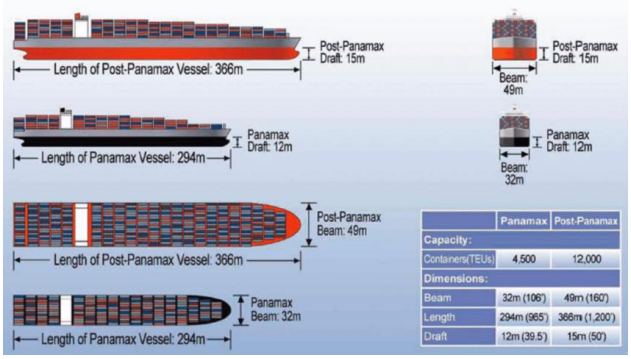


Figure 4: Comparision of Panamax and Post-Panamax container ship dimension [71]

Trend of Container Ships Size and Constrain

In early 2010s, most of the world's cargo has carried usually in container ships; capacity below10000 twenty-foot equivalent units (TEUs). The share of mega-container ships in global merchant fleet between 2011 and 2021 in percentage has been shown in figure 5 below [62, 63]. However, from 2011, mega-container ships with capacity above 10000 TEUs have introduced in the global fleet. So, from 2011 to 2021, proportion of container ships carrying capacity rose from 6 to 40% and below 10000 TEUs container ships have reduced gradually. The number of mega-container ships in global fleet has been shown in the figure 6 below. So, "in the last 10 years, there were 97 new ships with capacity 15000 to19990 TEUs and since 2018, 74 new ships with capacity 20000 TEUs and above were added to global container fleet. These mega-container ships have facilitated by advances technology, and have widen corporate strategies and have reduced cost. But, due to over tonnage in major liner routes, those have given pressure on infrastructure and port logistics" [63].

From March 23 to March 29, 2021, the Suez Canal was blocked (due to its sinking) by the mega-container ship Ever Given, which had 20,000 TEUs. This demand on infrastructure was clearly visible. In collisions, groundings, and other serious incidents, larger ships are therefore more challenging to steer, more difficult to control, and more expensive to rescue. Moreover, higher risks entail higher insurance costs and

which was burden for the whole industry. This is a critical issue for the global maritime transport network in particular to the Suez and Panama canals, which have constrained capacities [63]. 'Such sensitive disruption sends shock waves to the entire global supply chains. The Ever-Given incident has delayed the passage of hundreds of vessels through the Suez Canal. That incident has disrupted global trade, aggravated shortage of containers, leading congestion in ports and increased freight rates' [64, 65]. Few mega container ships and their container operation in ports have been shown in figure 7 below [78, 79, 80]. General arrangement of Emma Maersk class container ships has been shown in figure 8 below [81]. List of ten largest mega container ships in 2022 and their TEU caring capacity has been shown in figure 8 below [82].

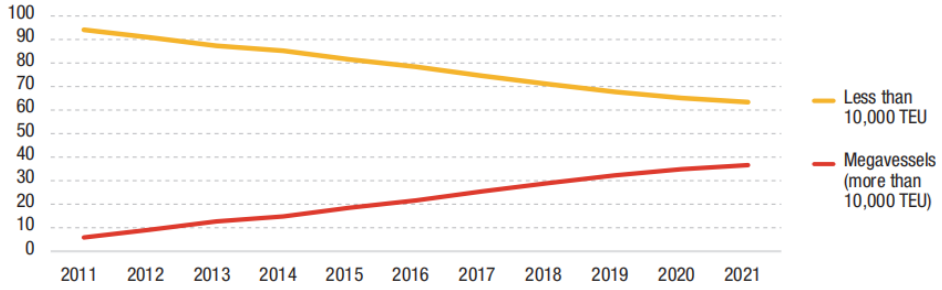


Fig 5: Share of mega-container ships in global merchant fleet, 2011 to 2021 in percentage [63]

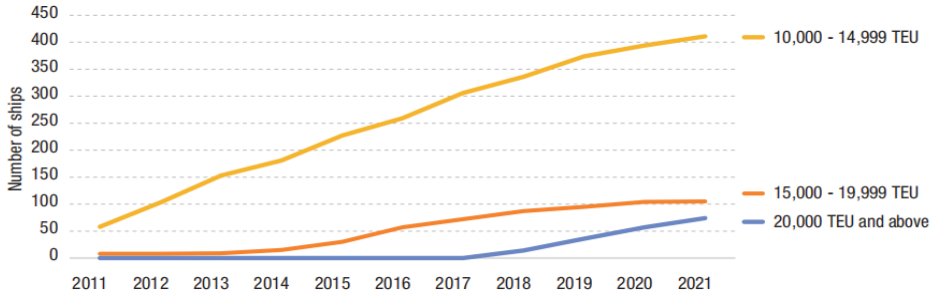


Fig 6: Number of Mega-container ships in global fleet [63]

Figure 7: Image of few mega container ships and container operation in port [78, 79, 80, 83]

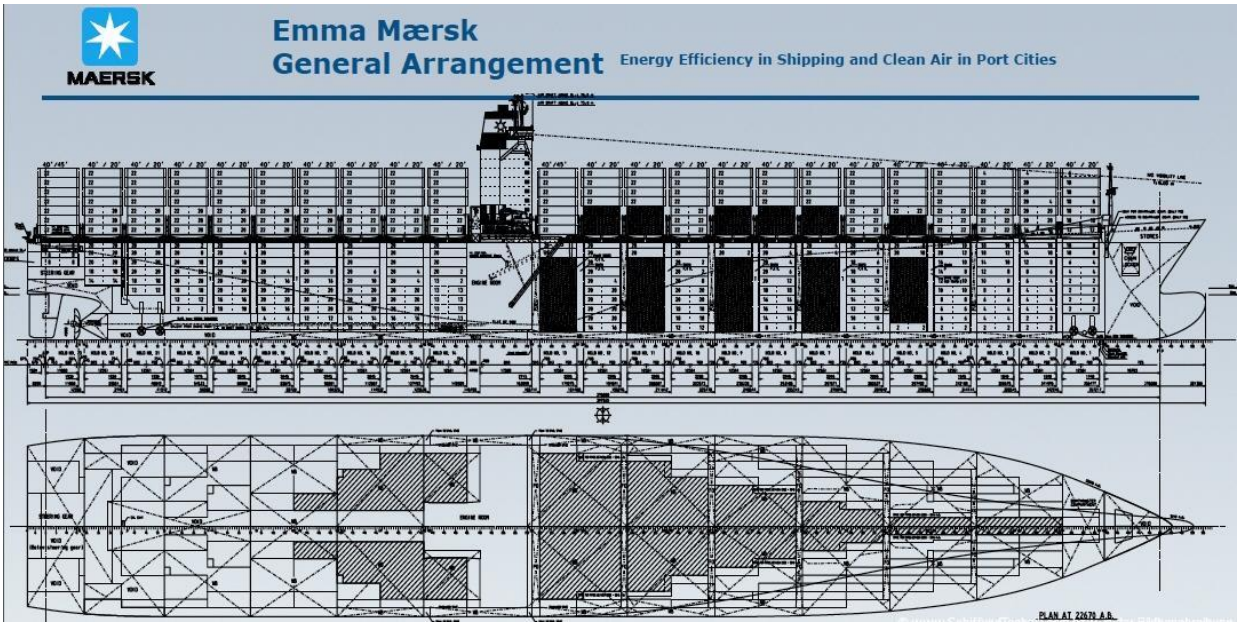


Figure 8: General arrangement of Emma Maersk class container ships [81]

Figure 9: List of the ten largest mega container ships with their TEU capacity in 2022 [82]

Efficiency, Innovation and Future Development of Containerships

Dry cargos are commonly divided into two main types: bulk cargo and break bulk cargo. Bulk cargoes (grain or coal) are transported as unpackaged in the hull of the ship; usually in large volume. On the other hand, Break-bulk cargoes are transported as packages in the container; usually in manufactured goods. Early days break bulk items were loaded, lashed, unlashed and unloaded from the ship one piece at a time before the

introduction of containerization in the 1950s. Today in grouping cargo into containers, up to 3000 cubic feet and about 29 ton, is moved at once and each container is secured to the ship. In the end, containerization greatly improved the efficiency of handling conventional break bulk cargoes while also cutting shipping time and costs by 35% and by 84%, respectively. According to data on cargo transportation in 2009, 125 million TEU, or 1.19 billion tons, of the world's total dry cargo was transported by container. There are seven usual size and categories of container ships: small feeder, feeder, feedermax, panama, post panama, new panama, and very or ultra large. Today there were 165VLCS or Very Large Container Ships class container ships in the world which can carry more than 10,000 TEU [14]. They can fit in 52 ports worldwide, which is interesting. Panama Canal's lock chambers limit the size of a Panamax vessel. Ships with a beam up to 32.31 meters, an overall length up to 294.13 meters, and a draft up to 12.04 meters can fit in the lock chambers. The largest modern Panama class container ship that can fit in the Panama Canal today is 366 meters long overall, 49 meters wide, and 15.2 meters deep in fresh water. A suezmax tanker or a capasize bulk carrier are more comparable in size to the new panama class container ships, which are wide enough to accommodate 19 rows of containers with a capacity of about 12,000 TEU [13].

MSC Irina is the world's largest container ship, with a capacity of 24,346 TEUs as of Jul 2023. She took her sea trials in February 2023 and was then sent to Zhejiang Zhoushan Shipyard for final work before come to the business. Recently the behemoth sailed on her maiden voyage and docked at Nansha Port. Her sister ship, MSC Loreto, with the same carrying capacity and dimensions, is also sailing under the flag of Liberia. Irina is the first among the six containerships and which would be constructed by the Chinese Jiangsu Yangzijiang Shipbuilding Group. These new containerships have unique design elements to decrease the consumption of fuel, such as propellers with a large diameter and an unique system that generates air bubbles along the hull to reduce water resistance. It is also fitted with hybrid scrubbers and that would decrease carbon dioxide emissions by 3 to 4% [83]. Actually the world's largest containerships are a very good example of the amazing achievement of engineering and advancement in the maritime industry as well as history. In the future, we may see more massive ships that may break the records of the ships as here mentioned. However, with their humongous size and carrying capacities, containerships have revolutionized the way in which goods are transported across the earth, enabling more cost-effective, efficient, user friendly and timely deliveries. On the other hand, we should keep in mind that these colossal container ships create many challenges and difficulties at the same time. They need special infrastructure and maintenance to operate at their optimum levels [84]. So, we may say, as the maritime industry continues to make more technological step forward and development, we will see super-mega size and more advanced containerships in near future.

Pollution and Safety

Today, shipwrecks and lost shipping containers threaten our harbours, coasts and sea. There has been a rapid increase in the worldwide containership fleet. In terms of value, global container trade now accounts for 60% of all seaborne trade and that is also increasing day by day. Whereas the quantity of goods being carried by containers has risen from 102 million metric tons in 1980 to 1.83 billion metric tons in 2017, and container ships have also increased their capacity and size [87]. Between 1980 and 2018, the DWT of container ships has grown from 11 million metric tons to around 253 million metric tons and the global container ship fleet has the capacity to carry more than 20 million standard containers and it become a colossal business activities all around the globe. On the other hand, container loss incidents in European waters are widespread. A number of global container carriers have suffered incidents over the years, and many of which go unreported. For the period 2008-2016, an average of 1,582 containers was lost each year, and 64% of which were from catastrophic events (and that usually defined as incidents in which more than 50 containers are lost). Recent incidents include the Mediterranean Shipping Company's ultra-large containership MSC Zoe; which lost around 342 containers overboard in German waters after being caught in heavy seas between Vlieland, Netherlands and the German Bight in the southeastern North Sea on 1st January 2019 [88]. This was the second largest reported container ship loss from a ship due to heavy weather. As we know that, the largest such bad incident was from the Svendborg Maersk; which lost 517 containers off the port of Brest, France, in February 2014.

The ever-increasing incidents of lost containers that are arriving on harbours, coastlines and beaches are now becoming an issue for coastal local authorities. However, the most of these incidents involve non-toxic pollution like, consumer goods, an increasing number of incidents are involving toxic material which adds a further burden to local emergency services. As the main providers of cleanup responses, usually Local Authorities have to bear the cost of clean-up [89]. There was estimation that container ships lose around 10000 containers annually. Generally, container over boarded on the open sea during storms. However, there are some examples of whole ships being lost with their all container [15]. If any containers are dropped, it immediately becomes an environmental threat and term as marine debris. Again, threat of piracy cost container shipping company around 100 million per year and that mainly near East Africa. Today there have been increased

concerns and those containers might be used to transport terrorist or explosive [13]. The US government has advanced the container security initiative (CSI), intended to ensure that high risk cargo is examined or scanned, sooner at the port of departure. Image of few worst container ship disaster and lose of containers incident at sea from ships has been shown in figure 10 below [34, 85, 86, 87].

Figure 10: Image of few worst container ship disaster and lose of containers incident at sea from ships [34, 85, 86, 87]

Global Ship Recycling State

Ships are generally removed from the fleet after end of life (EOL) through a process known as ship recycling or scrapping. Ship owners and buyers negotiate scrap prices based on few factors; ship's empty weight or LDT and prices in the scrap metal or recycle market. A total of 933 ships of a combined 44.4 million DWT were scrapped in 2016. In 2016, Bulker and containership recycling activity was very strong and accounted for 65% and 18% of total demolition respectively in terms of DWT. In term of DWT, Bangladesh represented the largest share of demolition activity as of today. Other potential ship breaking countries are Pakistan, Turkey, China, Denmark and Belgium. Major ship breaking countries and their share in no of EOL ships and gross tonnages of ships recycled in 2021 [7, 61] has been shown in figure 11 below.

Bangladesh Ship Recycling State

In Bangladesh, average 200 different types of obsolete ships are recycled annually in different yards located in Chottogram [2 and 3]. Again, from on ground statistics of ship recycling yards of Bangladesh, we can see that, average 2000000 LDT different types of scrap ships are recycled annually in different yards in Bangladesh [4 and 6]. According to a report by the United Nations Conference on Trade and Development [62], Bangladesh has once again surpassed all other nations in ship recycling in 2021, recycling more than half of all ships in existence. According to the publication 'Review of Maritime Transport 2022' published on November 29, Bangladesh recycled 8.02 million tons of EOL ships from January 2021 to January 2022, making up 52.4% of the global total, of which roughly 57% were oil tankers, 25% bulk carriers, and 9% liquefied gas carriers. In the previous year (2020), around 54% of the world's oil tankers, 18.4% of bulk carriers and about 5% of liquefied gas carriers were recycled in Bangladesh, as per the annual flagship report. Ship recycled by major vessel type has been shown in figure 11 below [57]. The average annual LDT and average annual reusable material output of six EOL container ships (from 2009 to 2015) has been shown in figure 12 below. The most basic level of the waste and reusable material flow diagrams for recycling of a sample container ship (out of 26), developed by software STAN [16 and 17], is shown in figure 13 and 14 respectfully in local yards in Bangladesh. The estimation and output of recyclable and waste materials for various types and sizes of six EOL

container ships has been shown in figures 15 and 16 respectively [6, 11, 16 and 17]. The detail and exclusive data, analysis, result, graph and output has been described in my Ph D research work.

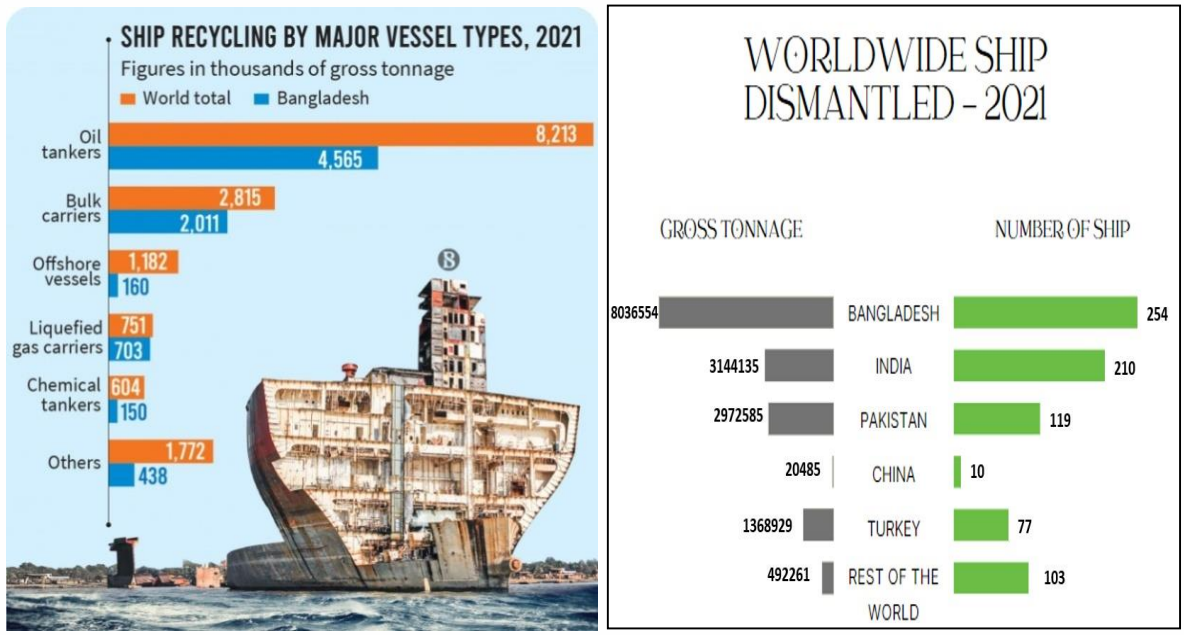
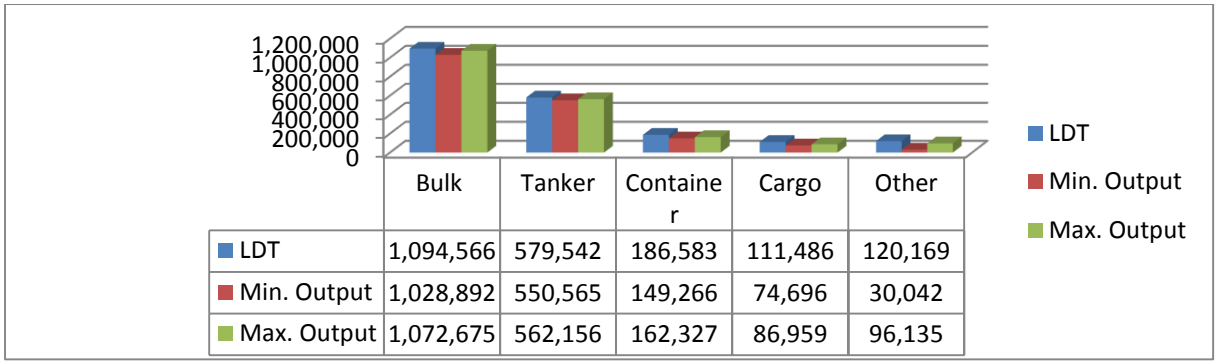


Figure 11: Ship recycling by major vessel types and number of ship by countries in 2021



	Bulk	Tanker	Container	Cargo	Other
LDT	1,094,566	579,542	186,583	111,486	120,169
Min. Output	1,028,892	550,565	149,266	74,696	30,042
Max. Output	1,072,675	562,156	162,327	86,959	96,135

Figure 12: Average annual LDT and average annual reusable material output (2009 to 2015)

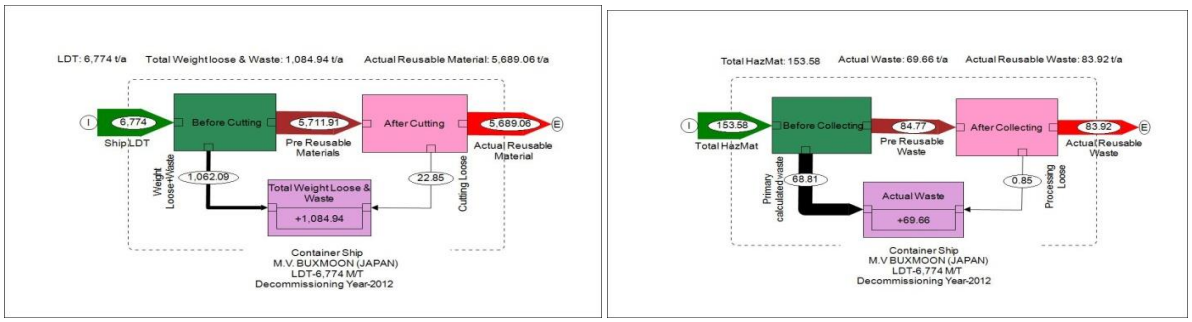
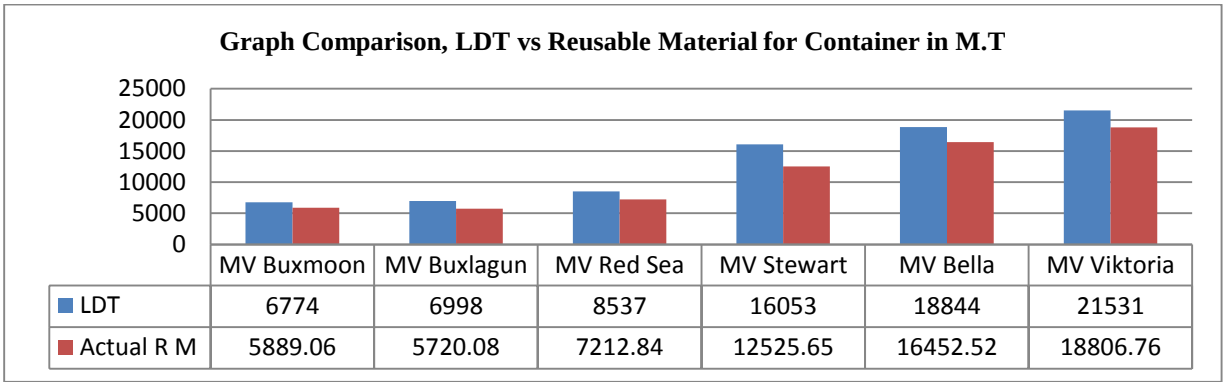
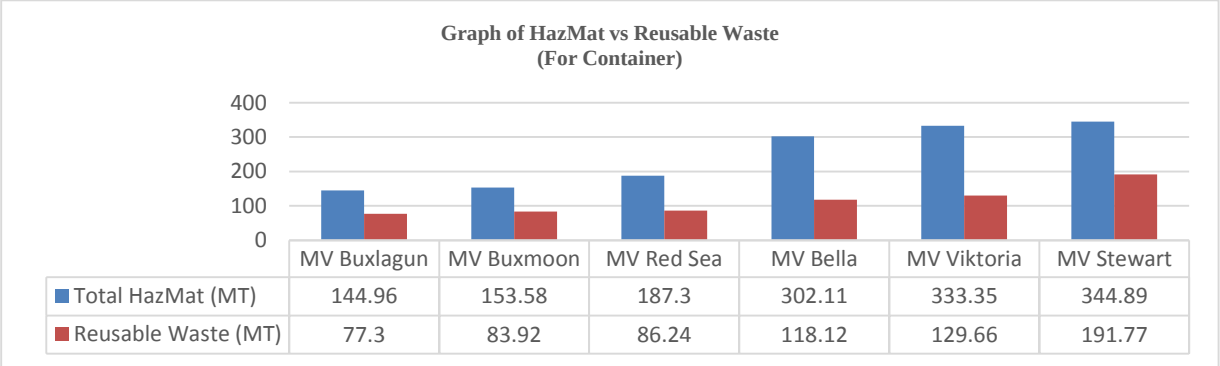


Fig 13 and 14: Reusable and Waste material flow diagrams of a sample container EOL ship.



	MV Buxmoon	MV Buxlagun	MV Red Sea	MV Stewart	MV Bella	MV Viktoria
LDT	6774	6998	8537	16053	18844	21531
Actual R M	5889.06	5720.08	7212.84	12525.65	16452.52	18806.76

Fig 15: Estimation and output of reusable material of different sizes of 6 EOL container ships.



	MV Buxlagun	MV Buxmoon	MV Red Sea	MV Bella	MV Viktoria	MV Stewart
Total HazMat (MT)	144.96	153.58	187.3	302.11	333.35	344.89
Reusable Waste (MT)	77.3	83.92	86.24	118.12	129.66	191.77

Fig 16: Estimation and output of waste material of different sizes of 6 EOL container ships.

II. Conclusion

Today most of the cargoes are now designed to fit precisely into containers. Additionally, just-in-time manufacturing was made possible by the dependability of containers since component suppliers could deliver specified components on a regular, predetermined timetable. Today, transport ships loaded with containers move almost 90% of all non-bulk goods worldwide. Again, 26% of all container transshipment is carried out in China. Only 20-foot, 40 feet, and 45-foot containers can be transported by container ship. 90% of all container transportation is done in 40-foot containers, which are the most common size. Now a day a converted container is used as an office at a building site. The term "shipping container architecture" actually refers to the use of shipping containers as the foundation for homes and other functional structures for people, whether as temporary or permanent dwelling, as a primary structure or as a cabin or workshop. In industries, canteens, shops, and even for any other business purpose, containers can also be used as shelters or storage areas. In 2016, a total of 933 ships with a combined DWT of 44.4 million were demolished. India, Bangladesh, Pakistan, China, and Turkey are home to some of the world's largest recycling facilities. In ship recycling yards of Bangladesh, average 2000000 LDT different types of obsolete ships are recycled annually, where 20% are container ship. Bangladeshi recycling yards are dismantling around 30% of global EOL ships including 20% of global scrapped container ship in term of DWT.

The doorstep for containerized maritime shipping has restricted the capacity of three of the world's major bottlenecks like, the Panama Canal, the Suez Canal, and the Strait of Malacca. The Emma Maersk class, introduced in 2006, is essentially a Suez-max ship. Ship designs for a Triple E Class; where 'E's standing for economies of scale, energy efficiency, and environmental improvement and that have been introduced in 2013 and revolutionize container shipping industry. However, their size would imply that only a few ports could handle them, and that was limitation of economies of scale. The ultimate future containership class would be the 'Malacca Max' with a draft of 21 meters. However, such supper-mega ship class would carry about 30,000 TEU and would be of such a dimension that no gantry crane equipment as of today has designed to handle. So, additionally, port facilities will be required to accommodate and handle such giant container ships. It has been found that, containerships in the range of 5,500 to 6,500 TEU appear as the most flexible in terms of the ports they can access and the market they can service and the most suitable for port calls. That's why; limits to economies of scale in container shipping are much more limited by commercial attributes than technical constraints. However, Naval architects, ship operators and engineers, and officials in the container business,

shipping, and marine insurance industries will continue their research for better, technically and commercially suitable, optimum sizeable and safer design and construction of containership for the future.

References

[1]. Churchill J.,"Ships for the long (and short) haul", AP Moller-Maersk (Press release), archived from the original on 2017-05-05, retrieved 2017-05-11.
[2]. Hossain, K. A., Story of Containerization, CPA Journal and News, Vol 4, Issue 3, Oct, 2019.
[3]. Hossain, K. A., Zakaria, N. M. G. and Iqbal, K. S., "Ship Recycling Prospects in Bangladesh," Proceeding of MARTEC 2010; International Conference of Marine Technology, BUET, Dhaka, Aug 2010.
[4]. Hossain, K. A., Iqbal, K. S., and Zakaria, N. M. G., "A Study of Socio Economic and Ecological Impact of Ship Recycling in Bangladesh," The Journal of NOAMI, Vol 27-1, pp. 35-47, May 2010.
[5]. Lamb,T. , "Ship Design and Construction Vol. I. " Jersey City: Society of Naval Architects and Marine Engineers, ISBN 0-939773-40-6, 2003.
[6]. Hossain, K. A., "Ship recycling practice and annual reusable material output from Bangladesh ship recycling industry," Journal of fundamentals of renewable energy and application, Vol 7, Issue 5, Sep 2017.
[7]. Brennon Borbon, "List of All Ships Scrapped Worldwide in 2016" September 9, 2017, http://rstudio-pubs-static.s3.amazonaws.com/306134_ebb046c5dff146cdb01fccc14b45c635.html, accessed on Jul, 28, 2018.
[8]. Krzysztof L., "The containers ships, which really was the first?", Transport Means 2016, proceedings of the 20th International Scientific Conference, October 5–7, 2016, Juodkrante, Lithuania, 668–676, ISSN 1822-296X.
[9]. Levinson M., "The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger", Princeton University Press, ISBN 0-691-12324-1, Archived from the original on 2008-05-16.
[10]. Ebeling C. E., "Evolution of a Box". Invention and Technology, Dec 2016, 23 (4): 8–9, ISSN 8756-7296.
[11]. Hossain, K. A., "Calculation of Yearly output of reusable material of Ship Recycling Industry of Bangladesh," Journal of Recent Advancement of Petrochemical Science, Vol 5, Issue 3, Jun 2018.
[12]. "STX reveals design for world's largest container ship, SeaTrade Asia, May 2008,archived from the originalon 2008-12-24,Retrieved 2008-09-10.
[13]. https://www.marineinsight.com/know-more/10-worlds-biggest-container-ships-2017, accessed on Aug 30, 2018.
[14]. https://www.rina.org.uk/Container_Ships.html, accessed on Jun 13, 2018.
[15]. The Containerization International Market Analysis Report, World Container Census 2012.
[16]. Hossain, K. A., "Ship recycling status of Bangladesh and annual reusable material output," Journal of Toxicology, Vol 2, Issue 2, Oct 2017.
[17]. Hossain K. A., Material Flow Analysis Technique for Material Assessment of Ship Recycling Industry, Bangladesh Maritime Journal, BSMRMU, Vol 3, Issue 1, Jan 2019.
[18]. Podsada P., "Lost Sea Cargo: Beach Bounty or Junk?", 19 June 2001, National Geographic News, Retrieved 2008-04-08.
[19]. Hossain, K. A., "Overview of Ship Recycling Industry of Bangladesh," Journal of Environmental and Analytical Toxicology, Vol 5, Issue 5, July 2015.
[20]. Hossain K. A., Panama Canal: Maritime Engineering wonder, symbiosisonlinepublishing.com, Toxicology Journal, 2019.
[21]. Hossain K. A., SWOT Analysis of China Shipbuilding Industry in the Third Eyes, Journal of recent advancement of petrochemical science, Volume 4, Issue 2, Jan 2018.
[22]. Hossain K. A.,, Sustainable Ship Recycling Methods and Process for Global Major Ship Recycling Players, V 3, I 5, Open Access Journal of Toxicology, www.juniperpublishers.com, Nov 2018.
[23]. Hossain, K. A., Go Green ship recycling prctices, CPA Journal and News, Vol 4, issue 2, July, 2019.
[24]. Hossain, K. A., "Proposed Sustainable Ship Recycling Process For South East Asian Recycling Yards" 11th International Conference of Marine Technology, Proceeding MARTEC 2018, UTM, Malaysia, Aug 13-14, 2018.
[25]. Hossain K. A., Analysis of important steering factors which give Success to Global Shipbuilding Leaders, Journal of recent advancement of petrochemical science, Volume 4, Issue 5, Jan 2018.
[26]. Hossain K. A., Ship Recycling Process and Material Distribution Channel Model for Bangladesh Ship Recycling Industry, Vol 2, Issue 1, Journal of BIMRAD, May, 2021.
[27]. Hossain K. A.,"Development of an Assessment Model for Ship Recycling Industry in Bangladesh" Proceedings of the 2nd International Conference on Industrial and Mechanical Engineering and Operations Management (IMEOM), Dhaka, Bangladesh, December 12-13, 2019.
[28]. Hossain, K. A., "Material Flow Analysis (MFA) is A Better Tool to Calculating Reusable Material For Ship Recycling" 11th International Conference of Marine Technology, Proceeding MARTEC 2018, UTM, Malaysia, Aug 13-14, 2018
[29]. 29. Hossain, K. A., "Calculation of Yearly output of reusable material of Ship Recycling Industry of Bangladesh," Journal of Recent Advancement of Petrochemical Science, Vol 5, Issue 3, Jun 2018.
[30]. Hossain K. A., Suez Canal: The wonder of maritime world, symbiosisonlinepublishing.com, Toxicology Journal, 2018.
[31]. Hossain K. A. and Zakaria, N. M. G., Proposed viable ship recycling process for south east Asian recycling yards specially for Bangladesh, Procidia Engineering, 2018.
[32]. Hossain K. A. and Zakaria, N. M. G., Estimation of reusable and waste materials of ship recycling industry of Bangladesh, Procidia Engineering, 2018.
[33]. https://www.sciencedirect.com/topics/engineering/container-ship, accessed on 20 May 2023
[34]. https://cultofsea.com/ship-construction/ship-stresses, accessed on 20 May 2023
[35]. https://www.youtube.com/watch?v=q2Ih_z2laYw, accessed on 20 May 2023
[36]. https://www.youtube.com/watch?v=4U5WBzqYbnc, accessed on 21 May 2023
[37]. https://www.youtube.com/watch?v=hZpZ2GVxopM, accessed on 21 May 2023
[38]. https://www.youtube.com/watch?v=2v1OY1HEv_8, accessed on 21 May 2023
[39]. https://www.youtube.com/watch?v=M5rX5EWmWVk, accessed on 21 May 2023
[40]. https://www.youtube.com/watch?v=2uv87S1K-AA, accessed on 23 May 2023
[41]. https://www.youtube.com/watch?v=vxeREd3s_UE, accessed on 23 May 2023
[42]. https://www.youtube.com/watch?v=MRbLTPJljIA, accessed on 23 May 2023
[43]. https://www.youtube.com/watch?v=vZDQEzApUtc, accessed on 23 May 2023
[44]. https://www.youtube.com/watch?v=Y6dLb3uWvc8, accessed on 23 May 2023
[45]. https://www.youtube.com/watch?v=pNdughfkDbM, accessed on 23 May 2023

[46]. https://www.youtube.com/watch?v=Rk6wYywvE38, accessed on 23 May 2023
[47]. https://www.youtube.com/watch?v=PQxXDQ9LdbQ, accessed on 23 May 2023
[48]. https://www.youtube.com/watch?v=pBqwR6d7tgg, accessed on 23 May 2023
[49]. "Maersk Line shipping containers worldwide", Archived from the original on 2013-09-16., accessed on 23 May 2023
[50]. Van Ham, Hans; Rijsenbrij, Joan Rijsenbrij, Development of containerization success through vision, drive and technology (Online-Ausg. ed.), Amsterdam: IOS Press, ISBN 978161499147, 2012
[51]. Reederei Blue Star GmbH, "Bay Class Overview", Reederei Blue Star Fleet, Hamburg: Reederei Blue Star GmbH, Archived from the original on July 19, 2011, accessed on 23 May 2023
[52]. "New Largest Containership In The World 'OOCL Hong Kong' Christened haul", Archived from the original on 9 March 2020, accessed on 23 May 2023
[53]. Hossain, K. A., Tale of LNG and LPG Ships, Global Scientific Journals (GSJ), Vol 11, Issue 6, June 2023, ISSN 2320-9186.
[54]. Hossain, K. A., Tale of Buik Ships, Global Scientific Journals (GSJ), Vol11, Issue 6, June 2023, ISSN 2320-9186.
[55]. Hossain, K. A., Evaluation of local industry of Bangladesh including shipbuilding, Global Scientific Journals (GSJ),Vol 11, Issue 6, June 2023, ISSN 2320-9186.
[56]. Hossain, K. A., Evaluation of global and local ship designing software trend and way forward, Global Scientific Journals (GSJ), Vol 11, Issue 5, May 2023, ISSN 2320-9186.
[57]. Hossain, K. A., Analysis of present global ship recycling status and challenges for Bangladesh, Global Scientific Journals (GSJ), Vol 11, Issue 4, April 2023, ISSN 2320-9186.
[58]. Hossain, K. A., Technological advancement and future of warship building,International Journal of Research and Development (IJNRD), Vol 8, Issue 5, May 2023, ISSN 2456-4184.
[59]. Hossain, K. A., An overview of merchant ships, International Journal of Research and Development (IJNRD), Vol 8, Issue 6, June 2023, ISSN 2456-4184.
[60]. Hossain, K. A., Analysis of development trend of ship designing software and future of ship design, American Journal of Engineering Research (AJER),Vol 12, Issue 6, June 2023, ISSN 2120-0847.
[61]. Mohiuddin G., Hossain, K. A., and Ali M. T.,Evaluation of present ship recycling scenario and opportunity for Bangladesh, Journal of Environment and Analytical Toxicology (JEAT),Vol 13, Issue 4, April 2023, ISSN 2161-0525.
[62]. UNCTAD, 2023, https://unctadstat.unctad.org/shiprecycling, accessed on 03 Jan 2023.
[63]. Clarksons Research (2021) Shipping Review Outlook, June 2021.
[64]. Allied Market Research (2022) Shipbuilding market by types and end use, available at: https://www.alliedmarketresearch.com/shipbuilding-market, (Accessed on 29 Jun 2022).
[65]. UNCTAD (2021) Trade and Development Report 2021, Jan 2021, available at: https://unctad.org/webflyer/trade-and-development-report-2021, accessed on 04 Jul 2023.
[66]. https://commons.wmu.se/cgi/viewcontent.cgi?article=1279&context=all_dissertations, accessed on 13 Jul 2023.
[67]. https://marinersgalaxy.com/ultra-large-container-ships-need-know/, accessed on 13 Jul 2023.
[68]. https://www.aapa-ports.org/files/Panamax%20vs%20Post-Panamax%20comparison%20article.pdf, accessed on 13 Jul 2023.
[69]. Manuel E. Benítez, ACP (2009-01-19). "Dimensions for Future Lock Chambers and "New Panamax" Vessels" (PDF). ACP, accessed on 13 Jul 2023.
[70]. https://commons.wikimedia.org/wiki/Category:Feeder_ships, accessed on 13 Jul 2023.
[71]. https://www.researchgate.net/figure/Dimensions-of-Panamax-and-Post-Panamax-Container-Vessels-Source-United-States-Army_fig1_305331669, accessed on 13 Jul 2023.
[72]. Tramp to Queen: The Autobiography of Captain John Treasure Jones, The History Press, 2008, ISBN 978-0752446257
[73]. https://transportgeography.org/contents/chapter5/maritime-transportation/e-class-containership-evelyn-maersk/, accessed on 13 Jul 2023.
[74]. https://transportgeography.org/contents/chapter5/maritime-transportation/post-panamax-containerships-specifications/, accessed on 13 Jul 2023.
[75]. https://transportgeography.org/contents/chapter5/maritime-transportation/evolution-containerships-classes/, accessed on 13 Jul 2023.
[76]. https://transportgeography.org/contents/chapter6/port-terminals/mscdiego-2/, accessed on 13 Jul 2023.
[77]. https://transportgeography.org/contents/chapter1/the-setting-of-global-transportation-systems/idealx-first-containeriship-1956/, accessed on 13 Jul 2023.
[78]. https://www.businessinsider.com/congress-spends-billions-deepening-port-harbors-for-mega-container-ships-2022-1, accessed on 13 Jul 2023.
[79]. https://www.marketwatch.com/story/mega-container-ship-too-big-for-shrinking-trans-pacific-route-2016-05-09, accessed on 13 Jul 2023.
[80]. https://prosertek.com/blog/the-largest-container-ships-in-the-world/, accessed on 13 Jul 2023.
[81]. https://www.vesseltracking.net/article/emma-maersk-container-ship, accessed on 13 Jul 2023.
[82]. https://www.container-xchange.com/blog/mega-ships-and-their-impact-on-ports-and-shipping/, accessed on 13 Jul 2023.
[83]. https://www.marineinsight.com/know-more/top-10-worlds-largest-container-ships-in-2019/#1_MSC_Irina, accessed on 13 Jul 2023.
[84]. https://www.marineinsight.com/know-more/top-10-worlds-largest-container-ships-in-2019/, accessed on 13 Jul 2023.
[85]. https://tasmaniantimes.com/2021/06/3000-shipping-containers-fell-into-the-pacific-ocean-last-winter/, accessed on 13 Jul 2023.
[86]. https://www.vice.com/en/article/y3ddpv/giant-ships-are-polluting-the-seas-with-thousands-of-lost-cargo-containers, accessed on 13 Jul 2023.
[87]. https://www.sciencedirect.com/science/article/abs/pii/S0269749121007132, accessed on 13 Jul 2023.
[88]. https://www.kimointernational.org/action-areas/maritime-safety-and-pollution/, accessed on 13 Jul 2023.
[89]. https://www.sciencedirect.com/science/article/abs/pii/S0959652622038380, accessed on 13 Jul 2023.
[90]. https://www.sciencedirect.com/science/article/abs/pii/S0959652621020813, accessed on 13 Jul 2023.
[91]. https://www.isesassociation.com/50-years-of-container-ship-growth/, accessed on 13 Jul 2023.
[92]. https://oceansone.de/wp-content/uploads/2021/07/Alphaliner-and-Oceans-One-Gigamax.pdf, accessed on 13 Jul 2023.
[93]. https://repositorio.cepal.org/bitstream/handle/11362/46457/1/S2000485_en.pdf, accessed on 13 Jul 2023.
[94]. https://newatlas.com/marine/msc-tessa-worlds-largest-container-ship/, accessed on 13 Jul 2023.
[95]. https://blog.shipsgo.com/biggest-container-ships-in-the-world/, accessed on 13 Jul 2023.
[96]. https://www.sciencedirect.com/topics/engineering/container-ship, accessed on 13 Jul 2023.