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Setting Sail into the Future: The Evolving World of Cruise Ships

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Abstract: A passenger ship is a merchant ship whose main function is to carry passengers at sea. This category does not include cargo-ships with room for a limited number of passengers, such as the once popular twelve-passenger cargo ships at sea where passenger transport was secondary to the freight car. Now, ocean-liners and the cargo capacity of most cruise ships have been eliminated. Cruise ships are large passenger ships that offer pleasure seekers and adventure travelers. They have restaurants, bars, casinos, theatres, ballrooms, nightclubs, swimming pools, fitness centers, game center and shops onboard making it a complete floating resort. Again, the yachting and cruise ship industry has emerged through a combination of targeted marketing, innovation and consolidation. Many new features, facilities and brands have been introduced and launched, some have failed, many have been successful, and at many more were active globally at the start of the pandemic. However, there is a need to further encourage consumers, travelers and customers' confidence by high lighting the facilities, entertainment, longevity and history of innovation in the yachting and cruise ship industry. What has helped has been the industry's resilience in tailoring the onboard experience to better reflect the social changes taking place ashore and travel industry. However, future travelers, users and customers will be more interested and adventurers towards the cruise ship industry. This is a review article that briefly tells the story of cruise ship with history, operations, design, construction, technology, safety, and recycling.

Keywords: Passenger Liner, Cruise Fleet, Tourism, Azipod, Eco-Ship, Peace Boat

1. Introduction

The development of coastal and marine tourism represents a important element of the blue economy and its capability and capacity is usually help to global civilization to attain the Sustainable Development Goals (SDGs). However, cruise ships ended their voyages in the 1970s, and the revival of cruise ships in voyage travel occurred with astonishing proportions. Before the Covid-19 pandemic, about 25 million passengers traveled around the world every year in cruise ships. The size and luxury of a cruise ship are major factors when one decides how to spend their vacation. Over the years, the cruise ship has grown tremendously due to its key role in the cruise industry. The trend is to build larger with more entertainment features cruise ships. In fact, the huge size offers more features, more opportunities, and more luxuries for entertainment, fun, games, and lower prices. The concept of cruise ships changes over time and the shipbuilding industry tries to meet the demand [7]. The huge and extremely luxurious cruise ships like, Oasis of the Seas [13, 94] and Harmony of the seas [14, 97] are illustrated in Figure 1 below. There are eighteen decks in Oasis of the seas, where engine space covers three under water decks. Itinerary details, amenities and services, including accommodations, floor plans, photos, sizes, types and categories of rooms or suites, furnishings and other essential details about Oasis of the Seas available can be obtained from the Royal Caribbean website and from YouTube [26]. The 3D design of the cabin is also available on the website [27, 31]. People are really surprised that, unlike our standard skyscrapers or mega-resorts, a cruise ship isn't built from scratch [33]. In fact, pieces of the ship were built off-site and then hoisted Tetris-style by giant gantry cranes. However, these pre fabricated parts can be a stall as four decks and take up half the width of

the ship.

Usually in a typical compound, the swimming pool is found on the ground floor, while the restaurants are most often located on the second or third floor, and the theaters are in their own buildings. On a cruise ship, though the swimming pools are stacked on the top deck for sun bathing; while the theaters are either in front or behind, since one cannot cross them. The layout of the cabin and internal arrangement of cabin is so that anyone can sleep soundly in their room. The dance floor is raised for an extra layer of sound absorption; all speakers are surrounded by sound-absorbing material; carpet is an absolute must; the walls are upholstered with the best sound-absorbing fabric a designer can find; and nearly every inch of the ceiling is clad with perforated sound proof tiles [95, 96]. Electrical and fire-fighting equipment in general should be completely concealed to facilitate complex plumbing networks. Designers struggled with shipbuilders and engineers to introduce document cabinets, mirrors, brightly lit ceiling panels and sky lights that create the illusion of higher ceilings, especially in larger rooms. But for some designers, creating the illusion of height for a cruise ship space starts with the walls. The huge cruise ships and their great looks can be seen in Figure1 below [94, 97].

Figure 1. *Mega cruise ships and their fantastic looks [94, 97].*

The actual construction of a cruise ship usually takes 2 to 3 years. However, the design plan is usually given a year in advance. Shipbuilding and construction process takes place in specialized facilities known as shipyards or shipyards. The cruise ship hull has designed by the shipyard with its own naval architect, while the interior and all special features were designed by the specialized designers and naval architects. Shipbuilders carry out shipbuilding, as well as ship repair; both of which are also known as ship engineering [36]. The reverse process (ship dismantling) is known as ship breaking or recycling. The largest recycling shipyards in the world are located in India (Alang), Bangladesh (Chattogram), Pakistan (Gadani) and Turkey (Aliaga). This is a brief review paper of cruise ship and that describedthe history of cruise ships along with pictorial descriptions, features, operations, design, construction, accidents, stability, technology, security, demolition, etc.

2. History of the Cruise Industry

We found from the history of cruise ship as ocean liners carried a lot of passengers from one point to another until the 1960s. But, as the wind blew the sails of modern industry and yachting as we see it today took shape. In the mid-19th century, the main purpose of passenger ships was to transport people across the Atlantic Ocean. The largest cruise ship of the time had amenities such as electricity on board; without luxuries and other amenities. The first voyage in history is often attributed to Augusta Victoria's two-month voyage to the Near East and the Mediterranean in 1891. The first largest cruise ship with a capacity of 241 passengers appeared in 190 and was built specifically for cruises. Her name is Princess Victoria Luise. The general manager of Hamburg-America Line, Albert Ballin, designed the ship. It was the largest cruise ship with an overall length of 124m at the time. The largest cruise ship Prinzessin Victoria Luise has been shown in Figure 2 below.

Figure 2. *The first biggest cruise ship Prinzessin Victoria Luise and a delighted night view of a modern Cruise ship [37, 38].*

The story of the RMS Titanic is really interesting. The shipping industry has found that a transatlantic trip takes as

little as four days. The companies tried to attract more passengers by adding different luxuries. It was the days of the RMS Titanic. It was the largest cruise ship in 1912. It is built by Harland & Wolff with a length of 269.06m and costs US$ 7.5 or £1.5 million. The RMS Titanic sank after a tragic accident during her maiden voyage. In the early 30s of the 20th century, Adolf Hitler, the Nazi leader, contributed to the development of the yacht industry. He tried to unite the nation by offering holiday packages to German workers. A comparison between the RMS Titanic and Allure of the Seas is shown in Figure 3 below.

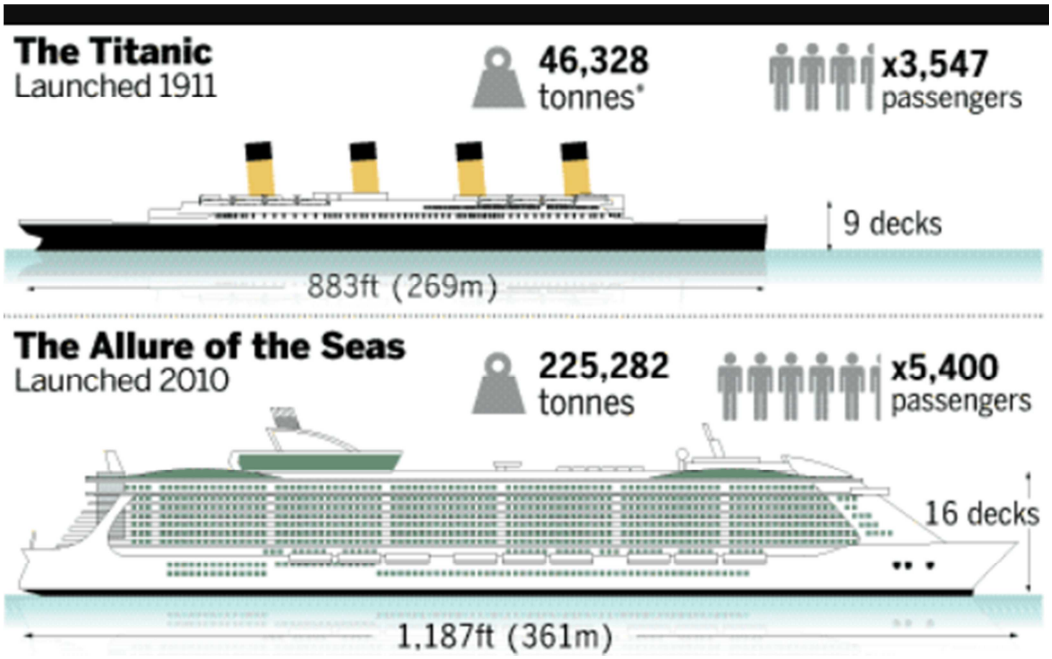


Figure 3. *Size comparison: Titanic vs Allure of the Seas Cruise Ship.*

The introduction of large passenger jets in the 1960s marked a turning point for the travel industry. People have replaced ships with planes for transportation. Cruise lines began to decline as cruise travel became more and more popular. The great success of the 1980s was the transformation of the SS France, the ocean liner and also converted into the largest cruise ship at that time as SS Norway [39]. The record for the largest ocean liner has long belonged to Norway. Their era ended in the late 1980s with the begging of the ruling class. They pioneered the introduction of glass elevators and multi-story skylights. They top the largest cruise ship rankings, and since the turn of the 21st century, the shipping industry has added at least nine cruise ships each year. The last largest cruise ship RMS Queen Mary 2 was built in 2004 [41]. It replaced the retired Queen Elizabeth 2 and remained the largest passenger vessel until the launch of the Royal Caribbean International Freedom Class in 2006. These ships hold the top spot in the cruise line rankings. Oasis class is the largest cruise ship in calendar to the beginning of the current rulers. The competition to build the most exciting cruise ship in the world continues, and the title of 'greatest cruise ship' is attractive to all travel businesses. The recent innovation period is Quantum of the Seas. It is now the largest cruise ship in the world. Quantum sails with devices such as iFly's revolutionary parachute simulator Ripcord and the Family-Connected cabin [42]. The Symphony of the Seas, the Caribbean's largest super-yacht, is shown in Figure 4 below.

The overall length, width, gross tonnage and capacity of a cruise ship are the main considerations for ranking the largest cruise ship. The top 12 largest cruise ships with its amazing features are shown in Table 1 below. A comparison between the RMS Titanic and Allure of the Seas has been shown in Figure 5 below. Today, cruise lines are a global business and have an economic impact of about $120 billion, according to a 2014 Cruise Lines International Association (CLIA) report released in 2014. These routes generate approx. US$39 billion in wages globally. At the same time, it also creates about a million jobs worldwide. A video link of the top 10 cruise ships has been given under reference 45. Cruises are perfect if we are looking for varied entertainment. Compared to planes or trains, cruises have their own charm and can be considered an integral part of a cruise vacation. Moreover, a cruise can also reach several different destinations, with enough time to enjoy the journey and the scenic spots. It is definitely worthy of a unique experience that no other mode of travel can match. The cheapest itinerary available depends on various factors. However, Carnival Cruises [86] tend to be very affordable overall, mostly with great options like Carnival Sunrise [87] and Carnival Horizon [88]. Royal Caribbean [89] is also another great cruise line with great deals if we consider our budget. Today, Innovative, overwhelming cruise ship fleet become full of adventure and great entertainment with megaships [90].

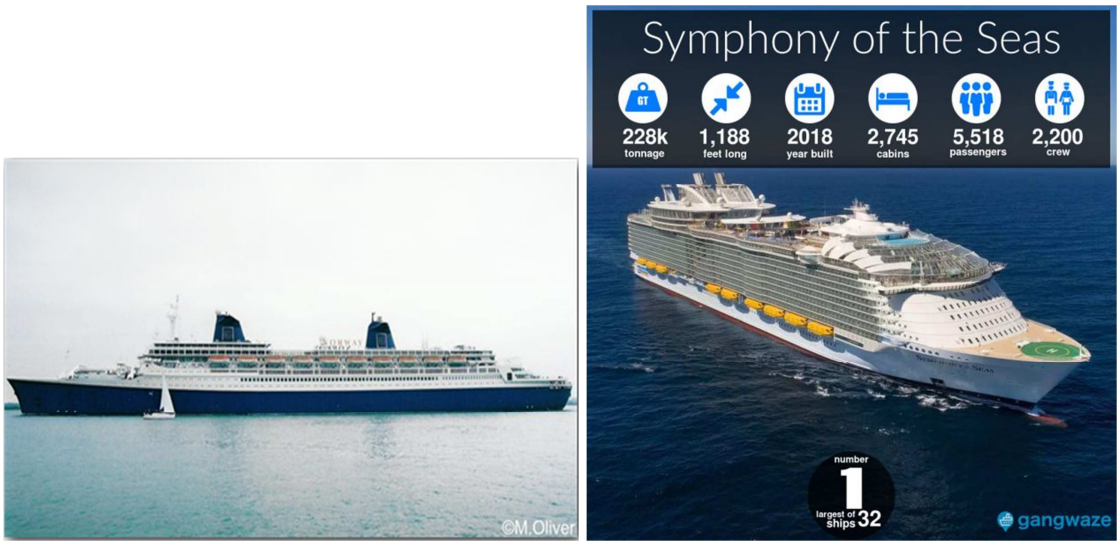


Figure 4. *The images of SS Norway, the first super-shipand the Symphony of the Seas, the biggest mega cruise ship [39, 40].*

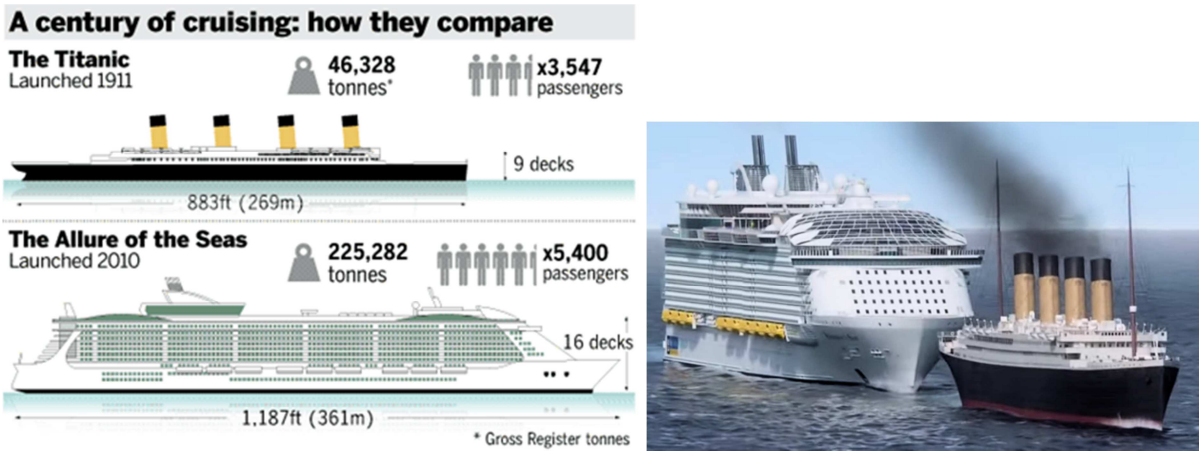


Figure 5. *The comparison between RMS Titanic and the Allure of the Seas [43].*

Table 1. *Top 12 giant cruise ships and their important information [94-102].*

No	Name	Line	Year	Gross Tonnage	Length	Capacity
1	Symphony of the Seas	Royal Caribbean International	2018	228000	362	7718
2	Allure of The Seas	Royal Caribbean International	2010	225,282	362 m	6,296
3	Oasis of The Seas	Royal Caribbean International	2009	225,282	362 m	6,296
4	Quantum of the Seas	Royal Caribbean International	2014	169000	348	5660
5	Norwegian Epic	Norwegian Cruise Line	2010	155,873	329m	5,183
6	Freedom of the Seas	Royal Caribbean International	2006	154,407	339 m	4,375
7	Liberty of the Seas	Royal Caribbean International	2007	154,407	339 m	4,375
8	Independence of the Seas	Royal Caribbean International	2008	154,407	339 m	4,375
9	Queen Mary 2	Cunard	2004	148,528	345 m	3,090
10	Norwegian Breakaway	Norwegian Cruise Line	2013	146,600	326 m	3,988
11	Norwegian Gateway	Norwegian Cruise Line	2014	145,655	326 m	3,910
12	Royal Princess	Princess Cruises	2013	142,229	330m	4,100

3. Present Cruise Ships Facilities

Today cruise ships require huge electric power and this is usually powered by diesel generators. Modern new cruise ships are powered by liquefied natural gas (LNG). When moored, ships must run generators continuously to power equipment on board, unless they are capable of using electricity on shore. Statistics show that polluting emissions from diesel generators can be equivalent to 700 trucks running their engines and are harmful when ships dock in densely populated areas. Modern cruise ships often have a lot of amenities, such as:

Casinos, boutiques, shopping centers, spas, sports centers, fitness centers, libraries, theaters with Broadway-style shows, movie theaters, Cineplex, card rooms, dispensaries and morgue, ping pong table, launderette, club, lounge, buffet restaurant, Jacuzzi, Observation room, Karaoke, Youth

lounge, Nursery, Indoor pool and/or outdoor with slides etc. Very few cruise ships have bowling alleys, ice rinks, climbing walls, parachute simulators, miniature golf courses, video game zones, zip lines, surf simulators, basketball courts, tennis courts, chain restaurants, rope obstacle courses and even rollerblading, roller coaster, etc. Few video links of 10 most luxurious cruise ships in the world have been given under reference 46.

Few people travel to the distant land known as the White Continent every year. Those often arrive by cruise ship, with small group experiences of up to 200 explorers at once aboard these highly seaworthy ships. If we go to the southernmost part of the world, we will find a quiet and beautiful region, inhabited by creatures that thrive in icy conditions amid rugged and beautiful landscapes. Antarctic cruises are becoming popular these days. Dozens of new dedicated expedition ships have been built or will be launched in the coming years, and many of these will provide routes to the Arctic and Antarctic regions. More than 55,000 people visit Antarctica each year, most of them from North America [46]. The outdoor layout and kitchen of a modern cruise ship have been shown in Figure 6 below [46, 95, 96]. The layout of the cabins of a modern cruise ship is illustrated in Figure 7 [47, 48]. The pool and theater layout of a modern cruise ship is shown in figure 8. The game and skating facility of a modern cruise ship is shown in figure 9 below [51]. Few video links from YouTube have been given here to see the facilities and amusement inside a modern cruise ship [141-147].

Figure 6. *Out fitting, Galley, dying, and other of a modern cruise ship [94-98].*

Figure 7. *Cabin Arrangement of a modern cruise ship [94-102].*

Figure 8. *Swimming pool and theater arrangement of a modern cruise ship [94-98].*

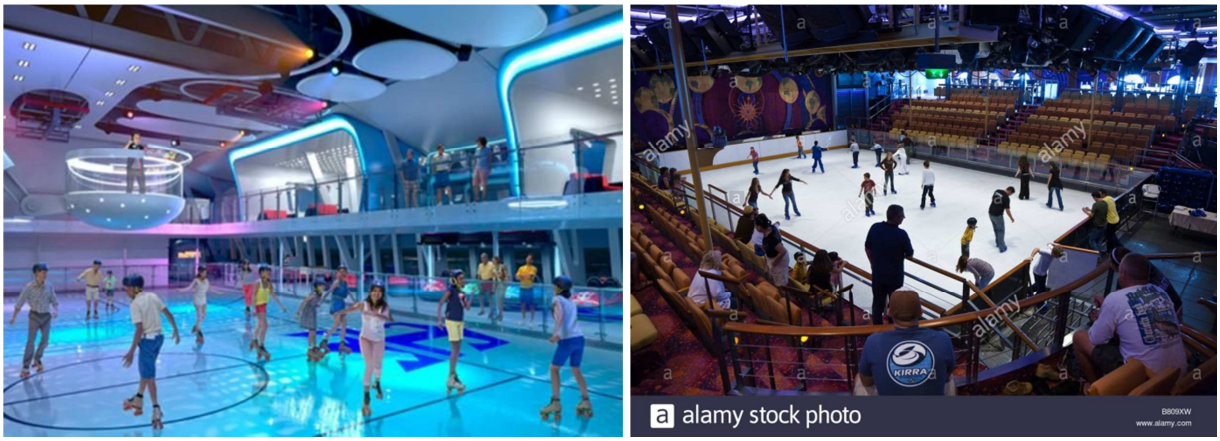


Figure 9. *Ice Skating and games of a modern cruise ship [95-98].*

4. Cruise Ship Stability

Cruise ships we see today are very colossal, but remain stable due to their reasonably low center of mass. It has been possible due to technological advancement and material development like, large open spaces and the wide use of aluminum, high-strength steel and other lightweight and composite materials in the upper parts. At the same time the heaviest components like engines, propellers, fuel tanks etc. are located at the bottom of the hull within bottom three decks. All modern cruise ships are very big, but due to proper weight distribution it ensures that they are not top heavy. Again large cruise ships are usably very wide, and that significantly increases their initial stability by increasing the metacentric height in some extent, and which is shown in Figure 10 below [49, 52]. However, most cruise lines use stabilizers to reduce rolling in heavy weather. The Fin Stabilizer is also shown in Figure 10 below. However, it is only for the comfort of the crew and passengers. It does not contribute to the intact stability of the entire ship. It's interesting to note that cruising has become safer over time. A video link of the top 10 cruise ship accidents and collisions caused by terrifying monster waves in a storm is shown at reference number 51. The accident and sinking of the cruise ships Costa Concordia and Titanic are shown in Figure 11 below [51, 56]. In the meantime, the cruise ship industry has grown rapidly in recent years. And air pollution from all kinds of ships is a serious problem around many harbors [117].

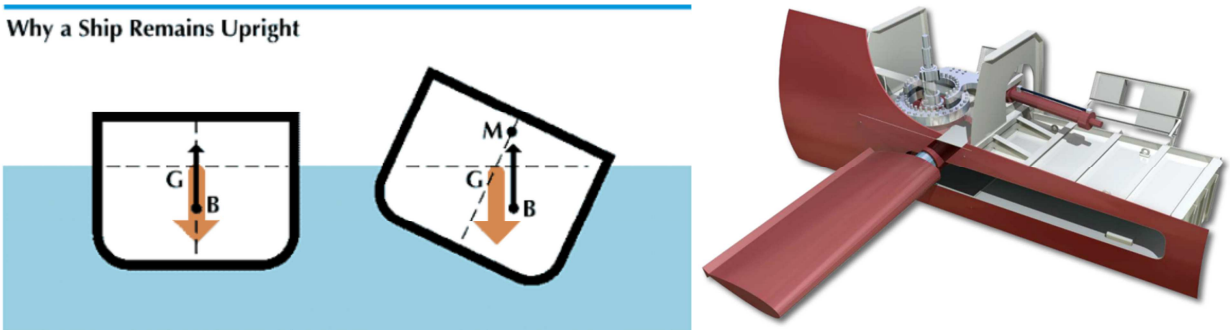


Figure 10. *Ships stability with upright condition and fin stabilizer [49].*

Figure 11. *Accident and sinking of cruise ships of Costa Concordia and Titanic [51].*

5. Cruise Ship Crew

Cruise ship screw is typically employed on 3-6 month contracts, which can be extended as often as necessary by mutual agreement. Crew and staff typically work 77 hours a week for ten consecutive months, followed by two months off. Off-duty and senior crew members receive paid vacation, medical insurance, retirement options and are eligible to join our group insurance plan. There are no crew or staff costs, as most staff rates include meals, lodging, medical care, and transportation. Few airlines often take advantage of potential employee desperation.

Cruise ships typically share a cabin with a shower, toilet, and desk with a TV between two employees, while senior officers are assigned separate cabins. Apart from passenger facilities, there are numerous facilities for crew and staff. Facilities include: Dining room, bar, lounge, prayer room, mosque, fitness center and crew deck with swimming pool. All crew members are required to have training, certifications and certificates of watch-keeping on board. Most of the well-known cruise line hotel staff are from low-industrial countries in Asia, Eastern Europe, the Caribbean and Central America. The International Labor Organization (ILO) sets precise standards for crew working hours, rest, health and safety and living conditions, and requires governments to ensure ships comply with them. The staff and crew of a modern cruise ship are shown in Figure 12 below [52].

Figure 12. *Staff and Crew of a modern cruise ship [52, 94, 98, 102].*

6. Global Cruise Lines Business

The 2014 CLIA Economic Impact Analysis, an independent study commissioned by CLIA and conducted by Business Research and Economic Advisors (BREA), found that the cruise industry contributed US$119.9 billion to the global economy in 2014, up from US$117 billion in 2014. This includes supporting 939,232 full-time employees with revenues of US$39.3 billion. However, direct spending by cruise lines, passengers and crew totaled US$55.8 billion [53]. CLIA's 2014 Asia Cruise Trends Study again showed that cruise tourism in Asia is growing at his double-digit rate in both capacity and passenger market. From 2013 to 2015, the number of vessels operating in Asia increased at a compound annual growth rate of 10%, while the volume of cruises and travel within and through Asia increased by 11%. Passenger capacity in Asia has increased by 20%.

Since the 2000s, most cruise lines have set some price on their cruise experience, as passenger spending on board far exceeds ticket sales. Again, your passenger ticket includes cabin accommodation, room service, unlimited meals and buffets in the main dining room or restaurant, access to shows, use of the pool and fitness facilities, housekeeping and there is a daily gratuity charge for waiter service. However, additional charges apply for alcoholic and non-alcoholic beverages, official cruise photos, internet and his WiFi access, casino and specialty restaurants. Cruise companies make a lot of money from selling shore excursions offered by local contractors. On these tours, bear him 50% or more of the passenger's expenses. In addition, cruise lines earn significant commissions from the sale of land-based businesses advertised on board, representing up to 40% of total turnover. Ports of call often have their own shops and facilities tailored to the needs of cruise ships. Transportation to and from the departure port is usually the responsibility of the passenger, but purchasing a cruise line transfer ticket for transportation between the airport and the cruise terminal guarantees that the ship will not sail until passengers have boarded [545]. Few luxury cruise lines sell their fares as all-inclusive. The fare may also include one night's accommodation for her in a hotel prior to embarkation and airfare to and from the cruise departure and destination ports [76].

7. Cruise Ship Construction and Design

Actually, ships are large, complex man-made objects designed to operate self-sufficiently in aquatic ecosystems for long periods of time while maintaining high levels of reliability. Ship design is a demanding process that requires the collaboration of various professionals with different and closely related requirements. Before the invention of computers, ship frames were made from reusable templates made on a drawing board. With the advent of technology, entire ships are designed using software. Pierre Bouguer (1698-1758)[81] and William Froude (1810-1879)[82], the fathers of naval architecture [79], were the founders of the important principles of ship design that now form the basis of the ship design and construction of maritime industry. Twenty-first century ships can carry thousands of people, vast amounts of cargo, vast numbers of weapons, and remain in the marine environment for months at a time. Vessels have already started integrating reusable and recyclable components, which may help reduce manufacturing costs in the long run [80].

Consider a modern cruise ship with 4,000 passengers and crew on board. Assuming that the water consumption of such a ship is about 300 liters per person per day, it will be 1,200,000 liters per day or she 1,200 tons. Again, the same cruise ship would require about 12 MW of power to keep everything running, which is enough for her city of 27,000 homes. The amount of solid waste on the cruise ship will be 6 tons per day, assuming about 15 kg of solid waste per person per day. Again, the amount of food waste will be 2 tons per day, assuming about 0.5 kg of food waste per person per day. The amount of wastewater is 100m3 per day, equivalent to about 25 liters of wastewater per person per day. The remaining water will end up as wastewater and should be treated as required.

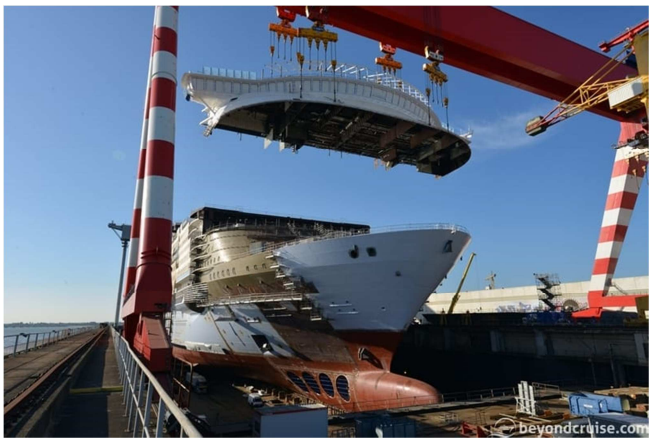
A day on a cruise is never boring. Spending time on a huge cruise ship is really interesting. Hollywood cruise and dinner with Marilyn Monroe and Michael Jackson look alike, anyone? There are also music, yoga, or a food and wine tasting trip? Many large cruise ships have gyms, jogging tracks, spas, as well as exercise areas, raw food, and healthy eating. Tourists can visit up to eight destinations on a nine-day river cruise around Europe, according to a study. That's twice as many tourists can visit on land tours. Statistics show that a typical cruise ship needs to wash at least 12,500 plates, 10,000 glasses and 15,000 pieces of cutlery every day. He has more than 2,000 ports around the world that cruise ships can call at. Carnival Cruise Lines alone puts more than 10 million chocolates on passengers' pillows each year. Allure of the Seas is five times the size of Titanic, weighing 225,282 tons and carrying 6,296 passengers compared to Titanic's 1,343. Silversea Cruises' "Silver Whisper" can cost more than $1.5 million per pair with a helicopter flight. Enjoy a 10-course Michelin-starred meal on board a private jet, visiting 28 destinations over four months [54].

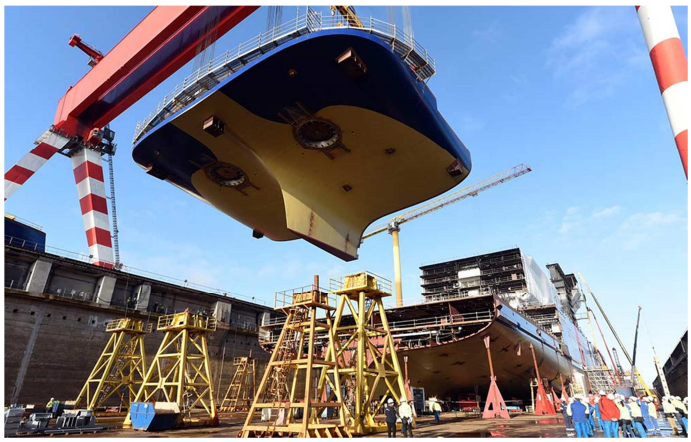
Cruise ship construction

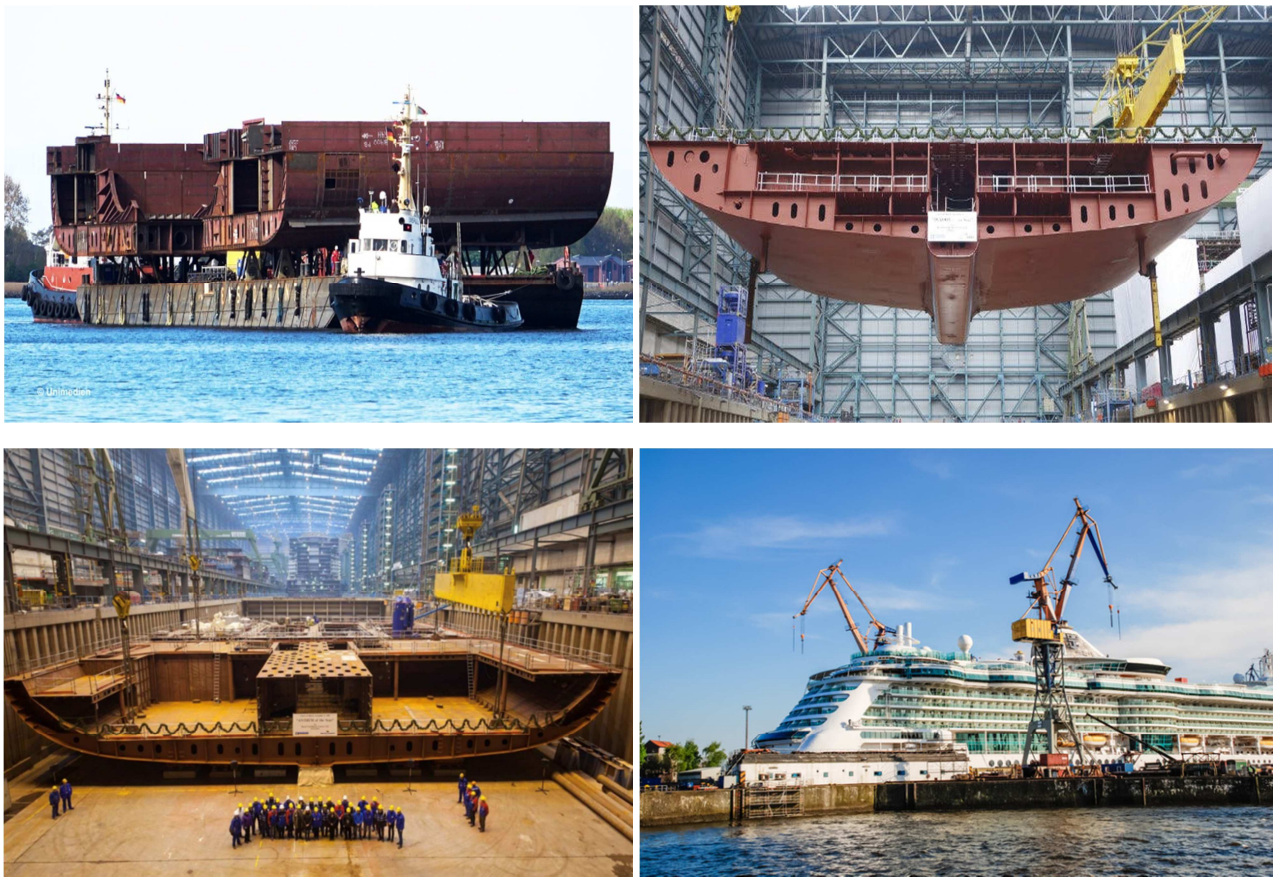
In fact, the cruise ship building process involves a number of complex research and testing procedures. Cruise ship design firms and their work are known as naval architecture. We analyze and provide solutions that meet the needs of the shipping and shipbuilding industry. This enormous and complex task usually begins with the submission of basic designs, detailed designs, ship equipment designs, engineering drawings and fabrication drawings to shipbuilders. The design office also uses the latest in his CAE (Computer Aided Engineering) technology to make analysis, simulation, diagnostic,

fabrication, repair and other data available to shipbuilding designers [20 and twenty four]. Cabin manufacturers can design and manufacture a variety of ready-to-install cabins and bathrooms for virtually any passenger and cruise ship for big and small luxury, ferry, RO-RO, ships. Shipyards also hire companies to provide so-called lifecycle services, mainly related to industry rules and regulations. Some of these services carry out upgrades and upgrades and keep them regularly up to date with new international rules and requirements [55]. Building large cruise ships from huge sections of prefab is common practice in modern times. The entire multi-deck segment is built off-site, transported via slipways to the shipyard, and lifted to the assembly site. This is commonly called a block or modular design and is shown in Figure 13(a) below. Sections may also be pre-installed with equipment, cables, pipes and other components. In fact, this saves a lot of time in shipbuilding and certainly saves a lot of money too. This technology was first used during the construction of Queen Her Merry 2 (2002-2004) by the French company "Chantier de la Atlantique". We can enjoy the video story of mega cruise ship Symphony of the Seas and the construction and float-out getting ready in 2018. Two video link have been given as ref [56, 139-141].

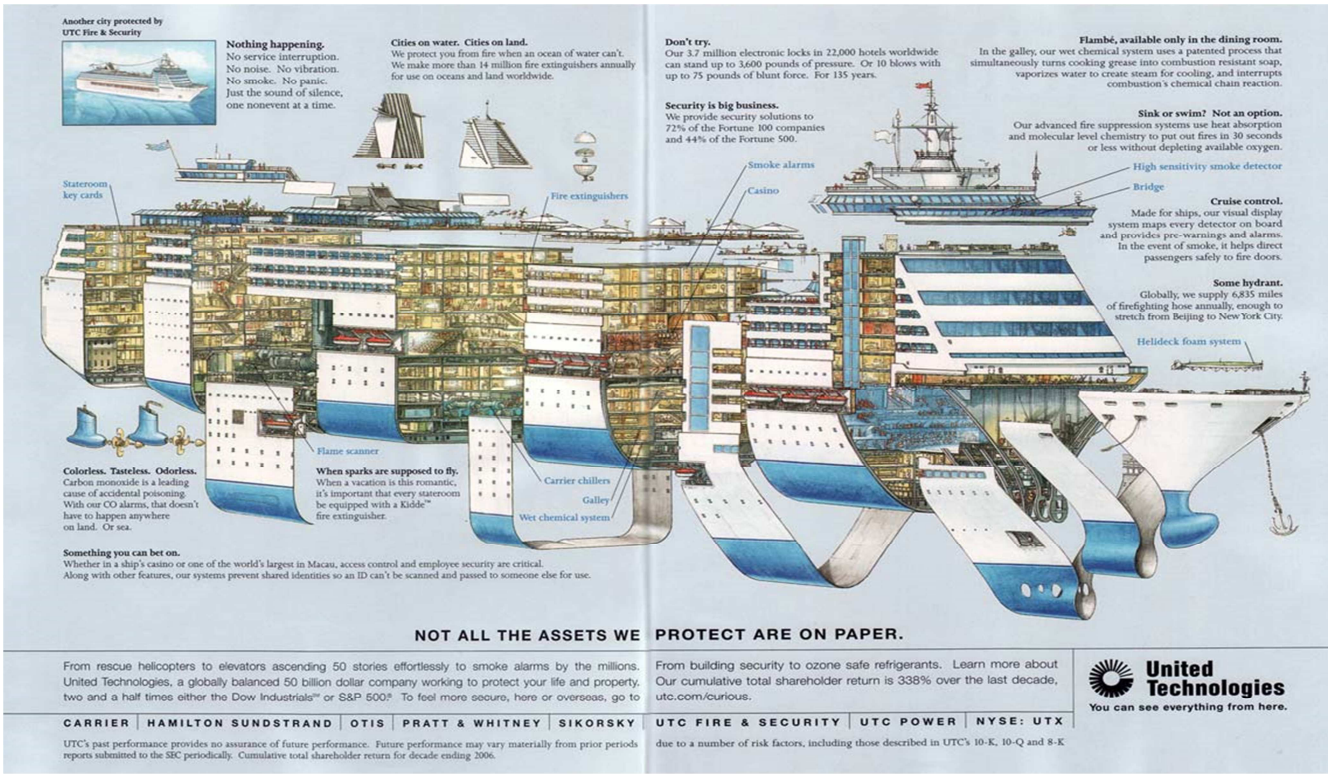
Modern cruise ship follows compartmentalized design and construction process. It also follows modern fire containment and safety systems. Modern cruise ship Bridge must be designed to facilitate best all-around visibility and comfort. Today's shipbuilding uses many innovations in construction, such as prefabrication, auto-welding, and computer-aided design [70]. The shift to prefabrication together with the innovations of special and automatic welding, which providing higher quality compared to riveting, and has improved cruise ship safety. Europe was shipbuilding's center in the Titanic era. It was buyer and employer of raw materials. Europe lost shipbuilding dominance a hundred years later, because of the cheaper Asian shipyards, specifically South Korea, Japan and China. After the change in the shipbuilding hub, a change in shipbuilding techniques was inevitable [71]. Today, the biggest part of construction of any big ship has not done at shipyards; theydo just assembly, not pure construction. Contemporary vessels arrive in prefabricated sections at dry-docks only to be welded together. Shipbuilders are likely to assemble several consecutive ships at the same time in series production. Actually section, block and modular ship construction change the total ship design and construction technology. Modern construction of cruise shipbuilding activities has been shown in figure 13 (a, b) below [130-135]; where a typical complicated cruise ship section and structural arrangement has been shown in figure 13 (b) below [129].







(a)



(b)

Figure 13. *(a). Example of block and modular construction [130-135]. (b). Complicated section and structural arrangement of a cruise ship [129].*

8. Present Cruise Ship Design Philosophy

Present cruise ships design in view of naval architecture and marine solutions are truly amazing and unique. Modern cruise ship is using the latest innovations, technologies and materials to ensure difference from other existing passenger ships. Special onboard features of a modern cruise ship, such as the Royal Caribbean ships' rock-climbing walls, ice-skating rinks, surf simulators, wave pools and the 9-deck high Zip-line are an irresistible temptation and a true allure for all the ship vacation fun fans. Again as to the common features, all big passenger ships and particularly mega cruise ship have a several decks high Atrium, at least 3 huge swimming pools, a Spa-Fitness complex, a grand casino, a library, duty-free shops, 2 huge capacity main restaurants, a grand theater, a disco, kids and teen areas, numerous bars and lounges, and all new big ships feature an open around-ship Promenade [21, 24]. As to the biggest of all - the Allure and the Oasis ships; each of them has 2706 cabins and that is nothing short to a floating resort. The structure of the cruise ship in dry dock and the structure layout of the cruise ship are shown in Figure 14 below [4]. A nice view of a modern cruise ship and a mega cruise ship (Royal Caribbean) is shown below in Figure 15 [96, 97, 112, 113].

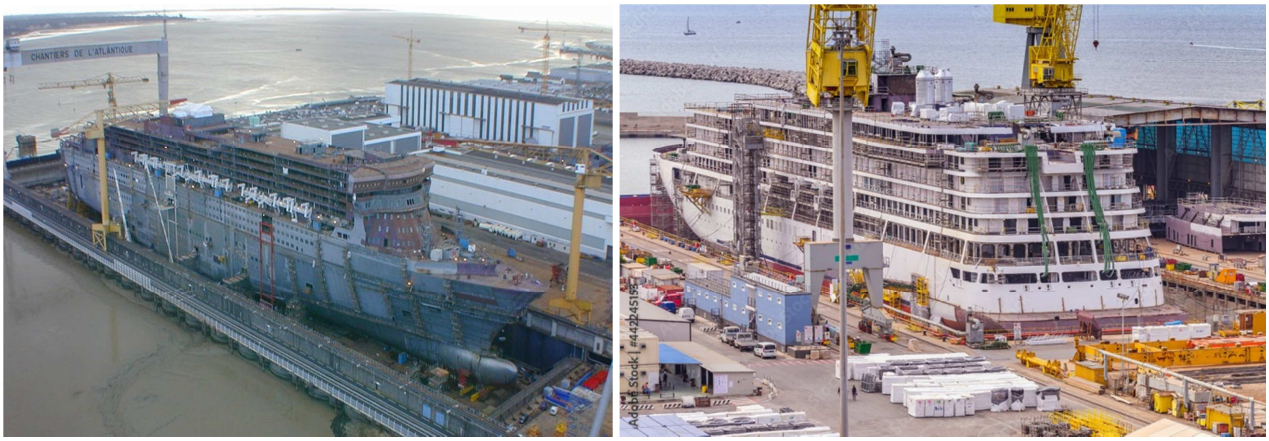


Figure 14. *Cruise ship constructionis on a floating dock and in a dry dock [4, 128].*

Figure 15. *Wonderfulfeatures of Royal Caribbean cruise liner [96, 97, 112-116, 126, 127].*

9. Present and Future Cruise Ship Engine, Power and Propulsion System

Today's cruise ships have some interesting technology, data and facts. Such as: hull, supper-structure, engines, performance, vessel propulsion systems, fuel economy, safety, pollution. The IMO (International Maritime Organization) has introduced a global sulfur content cap of 0.5% in marine fuels since 2020. If the vessel does not use a scrubber (environmental protection device), the owner of the old vessel may use marine fuel MGO (marine gas oil), ECA category fuel (low sulfur MGO), new reformate fuels and blends, LNG (liquefied natural gas), or electric/battery power. Each fuel option should be based on vessel type and age, route or route, and power plant. Most of the newly built cruise ships will be powered by LNG. The world's largest ports, as well as many smaller ports, already have onshore power systems that can power ships from shore to quay. In addition to the LNG bunker option, many ports also have onshore power. Without an energy source, a giant cruise ship is just a pointless floating hotel. However, many older ships use diesel reciprocating engines to generate power for propulsion. Figure 16 below shows the engine system and massive propeller of a diesel-electric cruise ship.

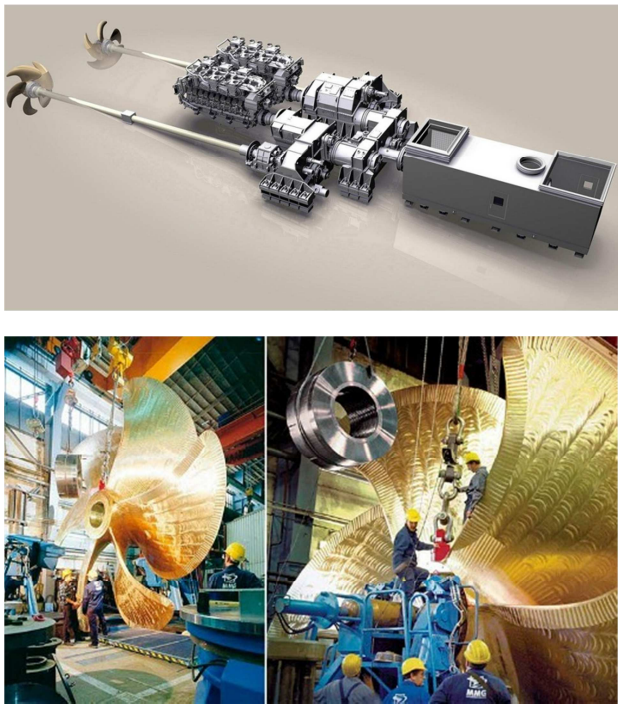


Figure 16. *A diesel-electric cruise ship engine system and a huge size of propeller [109, 110].*

Cruise ship engine power is transmitted to the propeller shaft through a gearbox. These gears determine the speed of

the propeller. Modern ships use diesel-electric engines or gas turbines as their energy source for propulsion and power generation. Today's large ships rely on her two sources of energy: One for power and one for propulsion. Gas turbine engines generate heat, which is converted from mechanical energy into electricity. To achieve this, compressed air is burned in the combustion chamber. Hot exhaust gases are produced by a turbine that mechanically drives the shaft. Electricity can be used to drive generators. Diesel-electric engines work similarly and use a direct drive system. The output shaft for producing electrical energy is connected to a generator. An important decision when designing a cruise ship is the location of the engine room. For stability reasons, the heaviest weight of the ship is placed on the lowest possible deck, so the engine is mounted above the keel. The bottom deck of the ship is almost completely filled with machinery. An engine room is a very large area that produces enough power to propel a huge cruise ship on the water. For this reason, the engine rooms of modern large cruise ships occupy at least three of her decks. Instead of long halls that run the length of the hull, the machines are mostly divided into small compartments: One for the main engine and one for heating or air conditioning.

This subdivision is done for security reasons. In the event of a hull breach or fire, multiple chambers help contain damage. Today's direct drive diesel engines have one big advantage. The use of shaft generators is also possible. This is a device that uses the circular motion of a propeller shaft to generate the electrical power required for hotel services such as cooking and lighting. Almost all new-buildings are equipped with diesel-electric drives. In these ships, the main engine is not connected to the propeller shaft, but directly to a large generator that produces electricity. This is then sent to an electric motor, which drives it to help propel the propeller. The main advantage of cruise ship diesel-electric engine systems is efficiency. This allows the main engines to run at near most efficient speed whether the ship is sailing at 5 knots or 25 knots. All vessels are equipped with emergency generators to maintain critical power supplies. The emergency generator is also mounted higher and outside the engine compartment to protect against damage and fire. The new ABB Azipods cruise ship propulsion system (see Figure 17 below) is more fuel efficient than previous systems. It also improves maneuverability, maximizes speed, reduces harmful emissions, optimizes overall vessel performance and improves passenger safety. ABB Azipod propulsion systems have a significant impact on cruise ship operational efficiency, reducing energy consumption and pollutant emissions by up to 20%. Azipod cruise ship propulsion systems are located outside the hull behind the hull. Azipod rotates her 360 degrees in all directions by means of a rudder and it provides propulsion in all directions. And that's not possible with conventional drives. Azipod is actually an electric propulsion system. A photograph of the two Oasis-class ship propulsion azipods and hull-mounted propulsion is shown in Figure 17 below.

The third ship of the Oasis class. Harmony of the Seas is currently the most technologically advanced and energy efficient cruise ship ever built. She is equipped with a new generation exhaust gas cleaning system, the so-called multi-stream scrubber. It also has a hull lubrication system that allows the ship to float on air bubbles generated around the hull. However, the steering and propulsion systems in azipod arrangement, are combined into one part and the system consists of a propeller (driven by an electrical motor) turned by rudder connected to the azipod system. The motor is inside the sealed pod and connected to the propeller. It is suspected that almost all future cruise ships will be upgraded with modern hybrid power plants that combine LNG-engines and batteries.

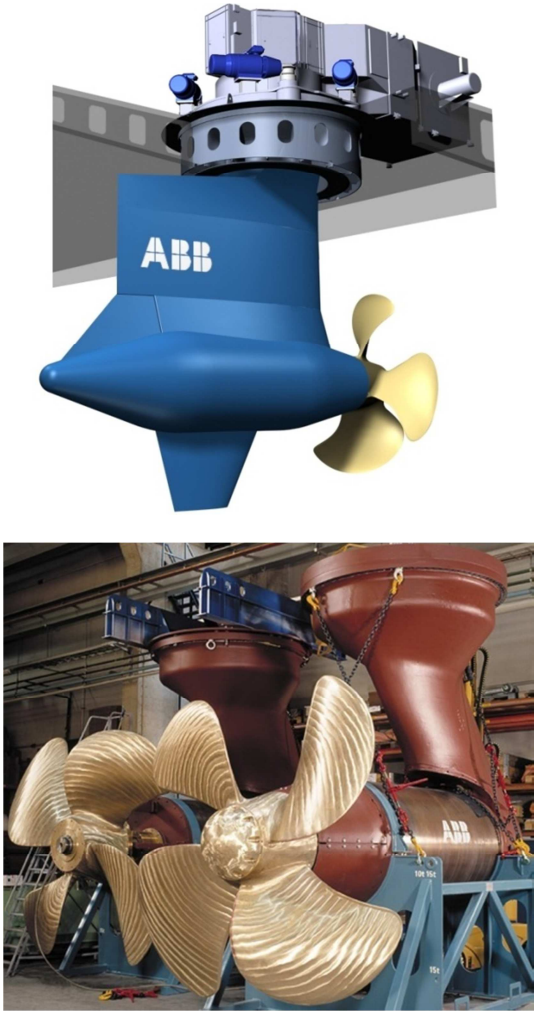


Figure 17. *ABB Azipod propulsion systems and Azipods (2 units) fitted on Oasis-class cruise ship [111].*

10. Cruise Ship Safety

Today construction techniques concerning cruise ship safety are far from the methods used for building the infamous RMS Titanic ship. In 1912, marine vessels have been pieced together in small dockyards by teams of skilled men and that was really a labor-intensive and a slow process. According to the SOLAS and latest cruise ship safety act regulations, passenger ships must have: Navigational aids

(echo sounder, AIS, ECDIS, radar), Voyage Data Recorder and DGPS precision position finding equipment. Cruise ship also has communications by satellite, VHF, GMDSS and EPIRB (Emergency Position Indicating Radio Beacon). Cruise ships must have up-to-date weather forecast system, including hurricane tracks, iceberg locations tracking, storm warnings. Cruise ships must have enclosed lifeboats and rafts with full crew and passenger capacity to accommodate all passengers and crew on board and also spare capacity. Cruise ships mandatory are the emergency immersion suites (inflatable life jackets) for all passengers and crew. Cruise ships have also helicopter pad for emergency rescue and long-range casualty evacuation services. Mandatory are also the passenger information system, crew training in emergency procedures, and safety drills. This shipbuilding industry learn very important design criteria, stability concept and other interesting ship construction procedures, so that present and future cruise ships are and will be more safer, comfortable and environment friendly [153].

11. Present and Future Construction of Cruise Ship Technology

Since from initial stage of cruise ship history, all luxury cruise ships and liners consume tons of fuel and produce huge sewage and that is often dumped directly into the ocean. However, cruises don't have to be overwhelming for the earth by design. Today's the newly-designed Eco-ship aims to be the most eco-friendly cruise ship on the seas. The futuristic vessel was envisioned by the firm Oliver Design for the Japanese humanitarian organization Peace Boat. According to Oliver Design [58], the Eco-ship will produce 30% less CO_2 than modern cruise ships. The vessel's electrical system has also been updated with both the solar sails and kinetic floors onboard providing power. The biggest change comes in the sewage operations: Both the waste and water will be fed through a closed loop, which means that whatever's produced is filtered and recycled again and again. Actually, it is continue to spread awareness due to the changing climate situation. The Eco-ship project is a new eco-friendly ship concept developed by Peace Boat, a Japanese non-profit organization that promotes human rights and environmental sustainability by organizing peace voyages on chartered passenger ships [59]. Few images of Eco-ship designed and Peace Boat has been shown in Figure 18 below [58, 119-124]. Two link of Eco-ship Oliver designed and Aquarius Eco Ship with zero emission ship design utilizing wind & solar power has been given as ref 149, 150.

Japanese NGO Peace Boat has commissioned Spanish naval architecture firm Oliver Design to build a high-range eco-friendly cruise ship. The Ecoship cruise liner will feature all the latest innovations in renewable energy use and is destined to become a benchmark for sustainability in maritime transport [119]. The Spanish firm has been working on the project since 2012 and has now completed the full architectural design of the ship, from the first sketches to the plan with the general layout of the vessel, including details of cabins and public areas, external 3D view, videos and other projection and display features [120]. In May, Peace Boat signed an agreement of intent with Finnish Shipyard Arctech Helsinki Shipyard Inc., and that was a major milestone in the development of the project. The aim was for the ship to be delivered to the Japanese NGO in time for the 2020 Olympic Games in Tokyo. This Eco-Ship is an ocean liner with a gross register tonnage of 60,000 tons, and capable of housing 2,000 pas has maximum speed of 21 knots and usually move in 17 knots [121].

French shipyard Chantiers de l'Atlantiquehas planned to construct cruise ships topped by striking 80 meter 'eco-friendly' paneled sails, and that made of fiberglass and carbon. The Solid Sail or AeolDrive concept would reduce cruise emissions by up to 50%, as the shipyard declared [136]. Cruise liner MSC Grandiosa and Celebrity Apex appreciate the concept and MSC Virtuosa, has built and inaugurated cruise at the yard [122]. The design of another eco-friendly sailing vessels that have made waves in recent past, from Oceanco's Black Pearl [137], and renowned for its three jet black sails and winner of the Super-yacht Awards Sailing Yacht of the Year in 2019 [122]. Chantiers de l'Atlantique reckons the Solid Sail/AeolDrivehas also work for the super-yacht market. However, they has keen interest for design of cruise ships. Due to the wake of the Covid-19 pandemic, many cruise companies suffering financial losses and the cruising industry face some uncertainty. Finally, MSC Cruises signed a contract to partner with Chantiers de l'Atlantique on future modern cruise ship projects [138], including the development of sail-fueled cruise ships [122]. On the other hand, the global cargo shipping industry accounts for roughly 25 of all greenhouse emissions worldwide. Soon, an advanced clean energy ship could finally deliver an eco-friendly solution for hauling freight across the ocean. Automakers understand that 'electrifying' the transport sector will be crucial in lowering dangerous emissions to mitigate a climate crisis. But two areas in which electrifying the transportation has proven to be difficult include commercial aviation as well as heavy-duty cargo shipping [123].

In past centuries navigation was based only on the forces of nature. Now Professor Vittorio GarroniCarbonara, an internationally renowned nautical architect, finally draws inspiration from it with a revolutionary project. Looking at the Super Eco Ship project and noticing the word a little strange. Actually, the future lies in the technology that the project intends to use; not only because it will almost certainly be the driving force behind the world in the coming years but also some aspects refer to technologies that are not yet tangible; but that maybe implement soon or later. Such innovative idea may give solutions of echo friendly ship and may achieve two objectives like: the greatest possible dependence on natural products and the need for less fossil energy. The proposed solutions minimize the necessary energy need and at the same time this energy source is

natural. So the proposed solution is totally eco-sustainable [124]. Proposed solution of echo cruise ship is going to revolution in future shipbuilding industry by using some innovative and advance technique like: the optimization of the hull, forward propulsion positioned immediately after the bulb, using stern bulb, use aft motorization system, multipurpose propulsion system, etc. Actually, aft motorization system consisting of a pair of ducted propulsors in which the tunnel itself is an integral part of the electric motor and where the blades are integral with the rotor as well as downstream are positioned a pair of pods with smaller diameter propellers with the opposite direction of rotation to the main ones and that improve the efficiency of the thrusters. The idea of electric motor-tunnels is to be explored in depth, and that is quite generic. Another purpose of the forward propellerswith adjustable axes has contributedeitherauxiliary propulsion or as a bow thruster. That's why it is known as multipurpose system [125].

Figure 18. *Image of Eco-ship and Peace Boat [58, 119-124].*

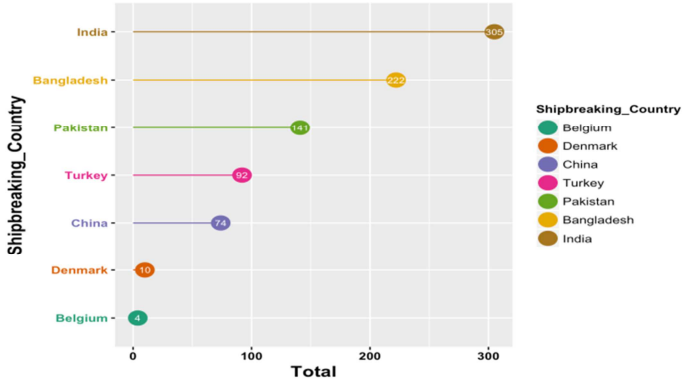


Figure 19. *Major ship recycling countries of the world in 2016.*

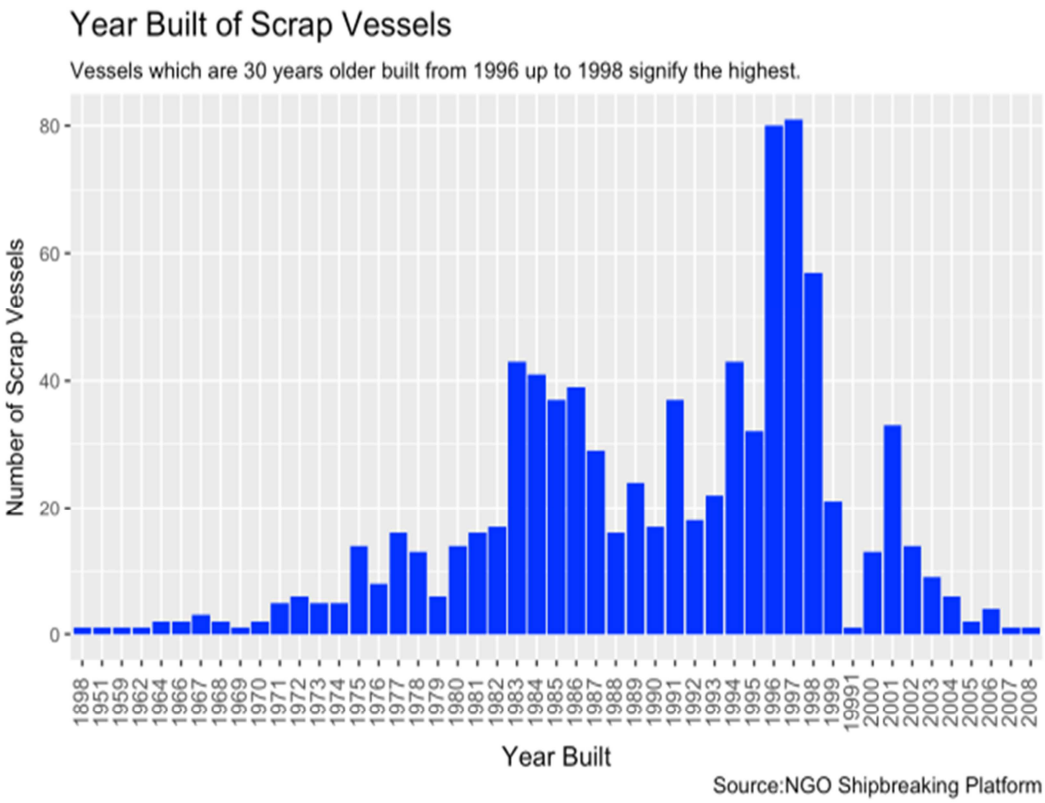
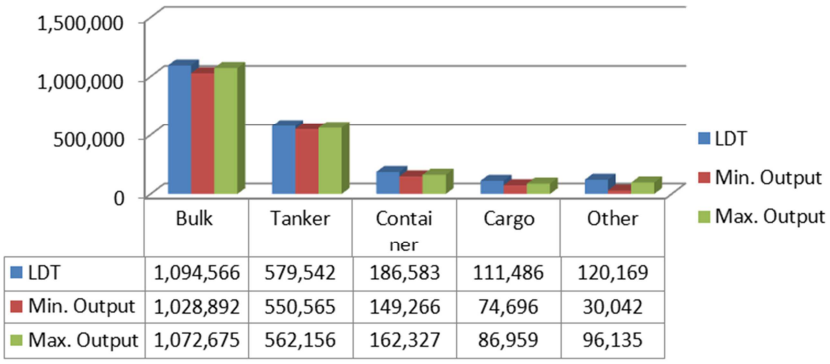


Figure 20. *Year of built of scrap vessel recycle in 2016 respectively.*



	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 21. *Average annual LDT vs average annual reusable material output (2009 to 2015).*

12. Global Ship Recycling State

All old ships, including cruise ships, are commonly removed from the fleet after their end of life (EOL) through a process known as ship recycling or scrapping. For example in 2016, 933 of her vessels with a total capacity of 44.4 million dead weight tons (DWT) were scrapped [1, 17, 28, 32]. In terms of DWT, Bangladesh accounts for the largest share of scrapping activity, with 199 ships totaling 13.6 million dead weight tons scrapped in Bangladesh in 2016 [18, 29, 34]. Other candidate countries for scrap include Pakistan, Turkey, China, Denmark and Belgium. The major scrap countries and their EOL numbers of scrap ships recycled in 2016 and their percentages by year of construction [27, 28, 32] are shown in Figures 19 and 20 above, respectively. In Bangladesh, an average of 200 types of obsolete vessels, including LNG and LPG, are recycled annually at various shipyards in Chattogram [28, 29, 32, 34]. Figure 21 above shows the total LDT for various vessel types and sizes, including gas-carrier recycling and reusable material production in recycling yards in Bangladesh from 2009 to 2015. Recycling yards in Bangladesh dismantle about 30% of her EOL ships in the world for her DWT [74, 78].

13. Conclusion

Coastal and ocean-based tourism contributes significantly to economic development around the globe and in the highly tourism-dependent Caribbean. The global market value of marine and coastal resources and industries is estimated at US$ 3.0 trillion per year, or about 5% of global gross domestic product (GDP). On the other hand, the contribution of the ocean economy to global value added has been estimated

conservatively to be on the order of US$ 1.5 trillion annually, or roughly 3% of global value added. Oceans enable domestic and international tourism for almost 200 countries and overseas territories. According to the UN World Tourism Organization, the cruise sector supports around 2 million jobs and contributes average US$ 150 billion to the global economy every year. The cruise industry has gone through significant changes from the days of transoceanic transportation and tropical vacations only available to the domain of society's elite, and to the modern multimillion tourism and leisure industry. Actually it offers an affordable vacation option and a level of comfort difficult to match for the average citizen, with a number of people cruising that seems to grow every year in the world. As the global ocean economy rapidly expands, presents increasing opportunities for and challenges to achieving sustainability in our ocean and on our coasts, particularly in the face of climate change and any pandemic like, COVID-19. The heavy dependence on marine and ocean resources is vibrant for the experiences cruise passengers consume. According to the Cruise Lines International Association (CLIA), the cruise subsectors in 2018 contributed US$150.13 billion to the global economy with increasing trend and continue in the future.

Today cruise fleets are growing faster and many cruise lines are launching brand new ships to meet unexpressed demand and accommodate higher guest space rates while offering guests a unique and contemporary cruise experience. We have seen the addition of a record 15 new vessels to cruise fleet in 2021. Cruise lines will continue to publish departures and destinations on their wish-lists, and we can book such travel at any time throughout the year. However, summer and spring are the best seasons for cruise travel. The Caribbean cruise line was the first to introduce onboard ice rinks, climbing walls, boxing rings, ziplines, 3D gaming, and surfing simulators, to name a few. Those ships feature the tallest slide at sea and the world's largest cruise ship. For example, Symphony of the Seas is his 1188 feet long, which is roughly the length of four football fields. In addition to existing cleanliness measures, cruise lines have adapted quickly by adopting new cruise ship health and safety measures and protocols to promote safety at sea. Ship designers, shipyard operators and engineers, cruise shipping and marine insurance industry players are encouraged to study how to design and build better, echo friendly, more enjoyable, peaceful and safe cruise ships for the future, so that this fascinating industry can grow further with more entertainment, luxury, comfort and success.

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