TECHNICAL PAPER

December 2021

Department of Naval Architecture and Marine Engineering

Military Institute of Science & Technology
Dhaka, Bangladesh

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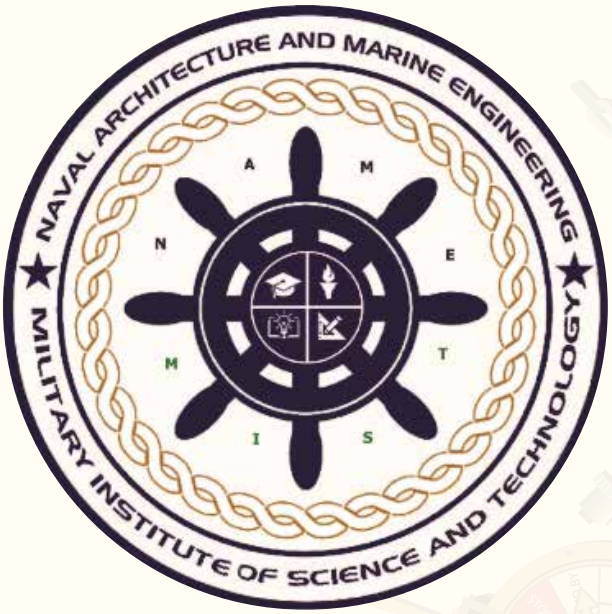

Department of Naval Architecture & Marine Engineering
Military Institute of Science & Technology (MIST)


বাংলাদেশের
সুবর্ণ জয়ন্তী
Bangladesh
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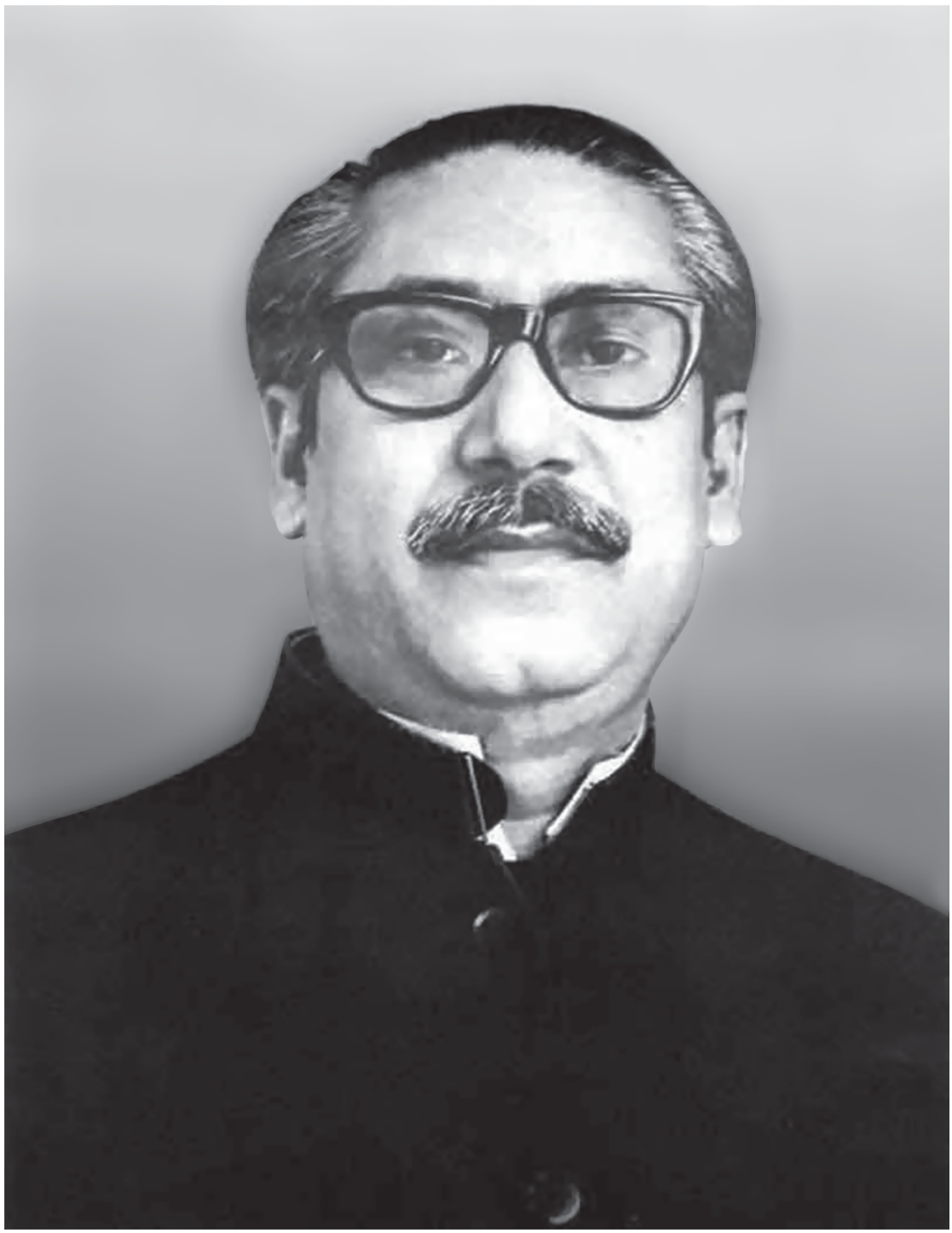
Father of the Nation



Father of the Nation Bangabandhu Sheikh Mujibur Rahman (1920 – 1975)

This Technical Paper is published on the occasion of the golden jubilee celebration of Bangladesh and is dedicated to the Father of the Nation Bangabandhu Sheikh Mujibur Rahman on his birth centenary celebration.

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Message from Chief Patron

I am glad to know that Naval Architecture and Marine Engineering Department of MIST is going to publish a Technical Paper on the occasion of 'Mujib Year', 100th year celebration of the birth of the father of the Nation Bangabandhu Sheikh Mujibur Rahman and 50-year celebration of our independence.

I sincerely hope that MIST will become a renowned maritime platform for technical personnel, engineers, maritime professionals and researchers at home and abroad. I wish to see NAME department continues to expand its horizon and become the center of excellence for providing service to the nation. I express my deep appreciation to NAME department for their great efforts in publishing the Technical Papers on this occasion.

Maj Gen Md Wahid-Uz-Zaman, ndc, aowc, psc, te
Commandant
Military Institute of Science and Technology, (MIST)

Message from Editor-in Chief

All praises and thanks to the Almighty Allah, Who comprehends all things in his mercy and wisdom. NAME department is going to publish a Technical Paper on the occasion of the long-awaited 'Mujib Year', 100-year celebration of the birth of the father of the nation Bangabandhu Sheikh Mujibur Rahman and 50-year celebration of our independence. It is my immense pleasure that we are the pioneer to publish a technical paper on this occasion.

Military Institute of Science and Technology (MIST) is an important partner in the maritime domain of Bangladesh. Shipbuilding and shipbreaking industry are the important economic multipliers in our country, especially for the employment of skilled and semi-skilled workers. These sectors have potentials, opportunities as well as challenges. MIST produces engineers, technical personnel and researchers to grab those opportunities and meet the challenges. To date, NAME department of MIST is honoured to graduate 175 naval architects who are carrying the MIST flag high in different sectors at home and abroad.

I would like to thank all the researchers, participants and writers without whom this paper would not be published within this short time. My sincere thanks also go to all the companies, industries, both government and private, seafaring personalities, researchers, academicians, professionals, stakeholders and my dearest students who have directly and indirectly contributed to the publication. I also like to express my deep satisfaction to editors and all faculty members of this department who have made great efforts to make this Technical Paper a success.

Commodore Khandakar Akhter Hossain, (E), PhD, NUP, psc, BN
Department of Naval Architecture and Marine Engineering (NAME), MIST

EDITORIAL

MIST is a premier engineering institution in Bangladesh. It aims to become the center of excellence in the field of engineering and technological advancement. NAME department takes pride to be an important platform to achieve that goal. NAME department is proud to publish this technical paper in Mujib Shoto Borsho, i.e. 100th birth year of Bangabandhu Sheikh Mujibur Rahman and 50 years celebration of Bangladesh. The technical paper published on the occasion is the first time in MIST of this kind.

This technical paper contains technical issues from renowned experts in their own sectors who have vast experience and knowledge of maritime affairs. The paper covers a wide range of technical issues and updated information on different maritime aspects. It also contains new ship designs submitted for ship design competition by the competitors from home and abroad. All the authors and ship designers have certified that the papers and ship design had not been published previously or not submitted for publication elsewhere and did not violate any security proprietary or copyright restrictions.

I had very short and limited time to complete this mammoth task of publishing the technical paper. Without the spontaneous support of my departmental members, it would not be possible for me to bring this technical paper at this height of quality. I respectfully acknowledge their invaluable contribution in every possible means. The editorial would not be completed if I do not express my sincere gratitude to our head of the department Commodore Akhter Hossain, (E), PhD, NUP, psc BN. He was a source of inspiration for all of us in the department to accomplish this mammoth task. We also thank our Commandant Maj Gen Md Wahid-Uz-Zaman, ndc, aowc, psc, te for his kind guidance and continuous support to bring our initiative a success.

I hope that this technical paper will prove its worth to the readers in a general gain of technical knowledge about maritime affairs and marine technology. I also expect that this publication would meet the thirst for knowledge of the readers in the respective fields.

Captain M Enayet Kabir, (E), psc, BN
Senior Instructor
Department of Naval Architecture and Marine Engineering

CONTENT

Classification Society Rules and International Regulations Addressing Seafarers' Comfort at Sea – Ship Design Perspective

Khondoker Shahriar Iqbal, PhD

A good night's sleep is a fundamental requirement for a worker to operate efficiently in any kind of job. Sufficient rest and sleep are not only a matter of personal comfort but also an important ingredient for a person's physical and mental well-being. Those who are working on ships are frequently encountered with dangerous and challenging situations, which are quite physically and mentally strenuous tasks for any person. In situations, keeping the nerve strong and working with deep concentration can only be achieved if the crews are given a proper relaxing environment and adequate rest for a significant period of time per day. This issue of the comfort of seafarers is termed as Habitability issue in shipping industries. According to the Maritime Labor Convention (MLC) 2006[1], which came into effect on 20th August 2013, the crews cannot be forced to work more than 14 hours in any 24-hour period and 72 hours in any 7-day period while at least 10 hours rest in a 24-hour period and 77 hours rest in any 7-day period is ensured. Sufficient rest and sleep may not be effective if the environment is not kept habitable. There are other ambient environmental issues like noise, ship vibration, indoor climate, lighting arrangement and suitability of accommodation areas etc., which more or less accounts for the ship design standards in making the life of crew members safe and comfortable.

Habitability issues are often ignored during ship design, partly due to the lack of awareness and partly due to direct cost involvement. So, to enforce a minimum level of comfort for seafarers, there are regulations enforced by International Labor Organization (ILO), International Maritime Organization (IMO) and Flag Administration. Though Classification Societies focus is to verify the safety of lives and protection of properties and environment, there are provisions of voluntary compliance on Crew Habitability while classing ships. This article will cover some of these features addressed in the Guide of American Bureau of Shipping (ABS)[2] and regulations from the International Labor Organization (ILO) and International Maritime Organization (IMO).

ILO is a specialized agency under United Nations with a mandate to advance social and economic justice through setting international labour standards. Title 3 of 'Maritime Labour Convention (MLC), 2006' adopted by ILO is to ensure that seafarers have decent accommodation and recreational facilities onboard ships. In this context, the Maritime Safety Committee of IMO approved the 'Guidelines on Fatigue' for ship crews[1] on July 2018 to ensure their alertness and ability to safely operate the ship or perform safety-related duties onboard ships.

ABS is a member of the International Association of Classification Society (IACS) and among the leaders in Ships and Offshore Installations classifications. The mission of ABS is "To serve the public

[1]International Labour Organization (2006), Maritime Labour Convention, 2006, including the Amendments of 2014, 2016 and 2018 to the Code of the Convention.
[2]American Bureau of Shipping (2016), Guide for crew habitability on ships, February, 2016.
[3]International Maritime Organization (2018), Guidelines on Fatigue, January 2019, MSC.1/Circ.1598.

interest as well as the needs of our members and clients by promoting the security of life and property and preserving the natural environment." ABS as a member of the classification society provides classification rules and guidelines for the design, construction and survey of various kinds of merchant and naval vessels, including Light Warships, Patrol and High-Speed Naval Crafts. In order to provide suitable habitat within the ship for crews at the statutory level, ABS has developed the "Guide for Crew Habitability on Ships". Three different types of optional habitability notation (HAB, HAB+, HAB++) have been offered by ABS under this Guide. Five major categories of habitability criteria can affect the task performance of the crew while serving onboard ships. These five categories are accommodation area, whole-body vibration (separate criteria for accommodation areas and workspace), noise, indoor climate and lighting. In addition to the HAB notations assignment, at the Owner's request, ABS may review the accommodation area design for compliance with ILO MLC, 2006 Title 3 requirements, in association with the MLC-ACCOM notations, which provide the guidelines for appropriate and decent accommodation and recreational facilities for crews working or living onboard ships consistent with promoting the seafarer's health and well-being.

At first, the resting place for a seaman should be of descent standard to make sure that his/her relaxation period goes uninterrupted and comfortable. Appropriate accommodation area design helps promote reliable performance by reducing the potential for fatigue and human error.

Accommodation spaces include cabins, medical facilities (sick bays), offices, recreation rooms, and manned spaces within the accommodation block, such as the bridge or control room. In ABS guidelines, accommodation areas also include service spaces such as mess rooms, laundry and storerooms. Appendix 3, "Accommodation Area Criteria" of ABS Guide2, provides the measurement criteria as well as criteria for access and egress along with crew cabins, sanitary spaces, offices, food services, recreation areas, laundry and medical spaces. For example, seafarers not performing the duties of officers in a ship with over 10,000 gross tonnage should be provided with at least 7.0 m^2 of living space for his accommodation no matter what would be the habitability notation used. On the other hand, an officer would get an almost similar amount of space in a similar ship with at most 9.0 m2 accommodation space for HAB++ notation.

Ship imposes a series of generally low-frequency mechanical vibration, as well as single-impulse shock loads on the human body. Low-frequency vibrations are also imposed by vessel motions, produced by the various sea states in conjunction with vessel speed. These vibrations can result in motion sickness, body instability, fatigue, and increased health risk aggravated by shock loads induced by vessel slamming. Vessel slamming may be caused by dynamic impact loads being exerted on the vessel's bottom or bow flare due to vessel size, speed and wave conditions. High frequency vibration influencing comfort is often associated with rotating machinery. Consideration of the vibration loads imposed on the body is restricted to motions transmitted from surrounding structures to the entire human body through the feet of a standing person in the frequency range 1 to 80 Hertz (Hz). Also, the acceleration at the point of contact with the human feet is also a measure to understand the comfort level regarding whole-body vibration caused by the motion of the ship. In this respect, at accommodation spaces, the root mean square value of the acceleration within the range of 107-178 mm/s^2 is considered to be within the comfort zone. For workspaces the range is within 143-214 mm/s^2.

Noise control is required to improve crew performance, communication and sleeping environment. To achieve acoustic insulation, a parameter named weighted sound reduction index2 (Rw) according to ISO Standard 717-1:2013 is used, which indicates a controlled noise level when Rw is kept within 35 from cabin to cabin, 45 in value from mess room, recreation room, public spaces and entertainment area to cabins and hospital, 30 from corridor to cabin and 30 from cabin to cabin with communication door. In terms of decibel level, the maximum allowable dB level for a vessel of over 10000 gross tonnage is around 110 dB at Machinery Spaces. Other than Open Deck Recreational Areas and Machinery Control Room, the noise level in other spaces should not exceed a value of 65 dB no matter what the gross tonnage of the ship is.

Lighting design is to provide adequate illumination for safety and well-being of the crews, as well as to facilitate various tasks performed onboard ships. Lighting criteria for various spaces are different. ABS "HAB" notations require the spaces like crew accommodation space, entrances and passageways, navigation and control spaces, service spaces, operating and maintenance spaces, red or low-level white illumination spaces to be designed to meet specific criteria. In section 6 of Habitability Guide2, Table 1 through Table 6 provide minimum level of illuminance in 'Lux' required for "HAB" notations. Most illuminated spaces in a ship should be at the Reading & Writing desk, meeting or training rooms and on Chart Table, where an illuminance level of 500 lux is required to be maintained to comply with the Guide requirements. In day light around Wheelhouse, Pilothouse and Bridge a level of 300 lux is recommended to be maintained.

To keep thermal comfort within the ship, the HVAC system shall be capable of providing an air temperature within the range of 20 to 25o C during winter months and 23 to 28o C during summer months. In HAB++ notation these ranges shall be capable of sustaining an adjustable manner by a temperature controller with access to individual crews. The HVAC system shall be capable of providing and maintaining a relative humidity within a range from 30 percent minimum to 70 percent maximum. The difference in temperature at 100 mm above the deck and 1700 mm above the deck shall be maintained within 3o C. Air velocities shall not exceed 30 meters per minute at the measurement position in the space. In crew cabin areas, the difference in temperature between the inside bulkhead surface and the average air temperature within the space shall be less than 10o C. The fresh/outdoor air supply quantity shall not be less than 8 liters/s per the number of persons for which the specific space is designed for.

To obtain a habitability notation under ABS Classification, design details indicating compliance with ABS Habitability Guide are submitted for engineering review. Then a vessel would be surveyed to ensure that it complies with the minimum criteria for accommodation areas and the ambient environment (i.e. whole-body vibration, noise, indoor climate and lighting). Prior to scheduling the Survey, the vessel owner or shipyard shall certify the operational status of the vessel as being fully operational and/or inclusive of all equipment and furnishings.

Seafarers typically stay away from home, family, friends for long periods of time which impose tremendous stress on their mental health. Ship designers always need to consider seafarers comfort in addition to engineering strength and safety requirements. Communication facilities like internet access and Satellite television may provide the crews with some amenities to spend their leisure times with ease and comfort. Other facilities like library of books, collection of movie DVDs,

availability of exercise equipment may also provide lot more provisions for the crews to enjoy their stay at sea. Moreover, the best incentive would be to provide all the crews with sufficient financial benefits which commensurate with the regulations of ILO.

Author's Brief Biography

Khondoker Shahriar Iqbal is currently serving as the senior engineer of the American Bureau of Shipping, Dr. Iqbal is a graduate of Naval Architecture and Marine Engineering from BUET and has done his PhD from Osaka University of Japan. He has served as the faculty member of Naval Architecture & Marine Engineering Department at Bangladesh University of Engineering & Technology for more than 20 years. In his career, he has also conducted extensive research work on environmental life cycle assessment (LCA) of the water transportation system and ship recycling. Dr. Iqbal was also an honorary visiting professor at engineering school named as ECOLE CENTRALE DE NANTES, of France.

Engineering and Technological Education in the Era of IR 4.0

Prof. Dr. M Rafiqul Islam

Introduction

The flow of knowledge, technology, economy, values, ideas from one country to another country affects in a different way due to a nation's individual history, traditions, culture and priorities which may be termed as Globalization. Whether we like it or not, we have to accept the fact that in the present-day world no nation can survive in isolation but to embrace globalization which should not be confused with the term 'internationalization'. In order to obtain the optimum benefits of globalization avoiding its pitfalls, especially in higher education system, we have to re-orient ourselves its structure and function particularly to meet the challenges of industrial revolution 4.0. This technological revolution will alter the way we live, work and relate to one another. We will not be able to ignore this technological innovation and we must be ready and make necessary preparation to meet the challenges of this 21st century's innovation.

We have missed the bus of the previous industrial revolutions. But we cannot afford to miss the benefits of the globalization that has been sweeping through the continents unfolding new opportunities not only for the privileged few but also for the underprivileged people around the world and posing new threats for those who are not prepared to face it.

Engineering Education and the IR 4.0

The world is currently witnessing scientific and technological changes at a pace and scale which is unprecedented in the history of human civilization. All universities in Bangladesh offering engineering education have started embracing these technological changes by aligning its education system, while at the same time addressing the issues related to IR 4.0. There will be a lot of challenges on business models, data ownership, communication protocol, displacement of workers. All these will be fueled by the increased use of robotics, artificial intelligence, internet of things raising the risk of inequality in labor markets requiring new skills and knowledge for employment. An important part of the tasks in the preparation for the fourth-generation industrial revolution is the adaption of the higher education matching the requirements of this vision, in particular the engineering education.

Things To Do

An engineering and technological university should have a number of basic ingredients which include: bright students, brilliant faculties, modern management and academic leadership, state-of-the-art infrastructure, financial strength. In most of the universities offering engineering education, we have these ingredients. But we do not appreciate the need for taking immediate steps to make the best use of the available facilities. In my humble view, the most important prerequisite for taking the benefit of the fourth industrial revolution is to change our mindset and to nurture a culture conducive for accepting positive changes that are taking place in the best practice universities around the world. Then we should be to create a strategic plan of the universities in consultation with the stakeholders and prepare a road map with specific and measurable milestones to implement it.

Emphasis on Undergraduate Education

The immediate efforts should be directed to give a solid foundation for undergraduate education through Implementation of Quality Assurance in engineering and technical education. Self-Assessment of all undergraduate programs should be carried out based on: Governance, Curricula Content Design and Review, Student Admission, Progress and Achievement, Physical Facilities, Teaching Learning and Assessment, Student Support Services, Staff and Facilities, Research and Extension Services and Process Management and Continuous Quality Assessment by getting feedback from the Students, Alumni, Employer, Academic and Non-academic staff. The assessment report should be assessed/peer reviewed to prepare a comprehensive improvement plan to meet the technological challenges.

The IR 4.0 requires the perceived skills on critical thinking and analysis, problem solving, self-management, working with people, use of modern technology and physical abilities which needs implementation of Outcome Based Education (OBE). The concept of OBE is 'Begin with End in Mind'. At the end of educational experience, each student must have achieved the standard outcomes.

Due to rapid technological changes, the higher education system has to reorient to adopt the changes. The graduates should be ready to cope with the changes specially to face the IR 4.0. IR 4.0 demands changes in contents of technical education in particular and education in general. Across disciplines, new emphasis will have to be given on certain skills and new contents have to be added to curriculum such as Artificial Intelligence, Big data and Analytics, Machine Learning, Internet of things (IoT), Data Science, Image Processing, Data Mining etc. at the same time. It is always needed to have a very strong senior and mid-level faculty members for long-term sustainability of the university.

Strong linkage should be established with industries through industry-academia collaboration, Industry problems should be collected to solve them through undergraduate and postgraduate projects. The university must produce highly creative graduates. Irrespective of discipline, graduates should have the ability to think critically, be innovative and entrepreneurial and have cognitive flexibility to deal with complexity, have ability to co-working not only with man but also with robots, have the intention to share knowledge apart from having the skills of good communication, collaboration, teamwork, problem-solving, entrepreneurship, leadership, emotional intelligence, etc. Self-learning skills in order to remain relevant to the era of rapid changes which needs implementation of innovative teaching and learning by using modern technology, such as online educational platform e.g., Moodle, Youtube video of lectures, Massive Open Online Courses (MOOC) etc.

Professional lecture series should be arranged regularly by inviting professionals from industry and academia. This series will provide an opportunity for students to learn about professional development from people who have been successful through creative solutions, hard work, networking and maybe even a bit of luck.

Emphasis on Post Graduate Education and Research

University should give emphasis on strengthening and modernizing postgraduate education and

research with a view to coping with the digital era. Adequate importance is to be given on research in addition to teaching to create new knowledge for the development of the society and research culture is to be established through motivation and providing research skill support training.

As Bill Gates said: I believe in innovation and that the way you get innovation is you fund research and you learn the basic facts. Therefore, I believe that every university should have adequate budget to provide funding for doing research and innovation and establishment of a Research Management Centre may facilitate the overall management of research activities of the university including the funding management for doing research. A plan is to be made to develop some specialized laboratories based on engagement of faculty with research.

Production and transfer of knowledge between universities and public and private organizations is supposed to be a two-way traffic and through this two-way traffic industries of the country will be benefited through their economic and social development. At the same time, through this mutual partnership university will be able to boost up financial strength by providing advisory/ professional services.

Conclusion

The proposals given in the article will ultimately stimulate our thinking and provide further impetus for positive and meaningful engagement for improving the quality of education at engineering universities to meet the challenges of IR 4.0. Let me conclude by quoting APJ Abul Kalam, "Dream, Dream, Dream. Dreams transform into thoughts and thoughts result in action.

Author's Brief Biography

Born on 19 March 1969, Professor Islam obtained with B.Sc. Engineering degree in Naval Architecture and Marine Engineering from Bangladesh University of Engineering and Technology (BUET) and stood first in first class in 1993. He was awarded M.Sc. Engineering degree from the same University in 1997 before being conferred on PhD from Yokohama National University, Japan, in 2001.

Starting his professional life as Lecturer in 1994, he went through the ranks to become Professor in 2009 at the Department of Naval Architecture and Marine Engineering, Bangladesh University of Engineering and Technology (BUET). A distinguished academic, Professor Islam held many leadership positions including Director, Institutional Quality Assurance Cell (IQAC) and Project Director, Establishment of Ship Model Testing Center (Towing Tank) at BUET and Member of many International Advisory Committees. In his chequered academic career, apart from BUET, Professor Islam also served as Professor at the Faculty of Maritime Studies, King Abdulaziz University, Jeddah, while as Visiting Professor at two Malaysian Universities; namely, Universiti Teknologi Malaysia (UTM) and Universiti Malaysia Terrengannu (UMT).

Dr. Mohammad Rafiqul Islam, Professor at the Department of Naval Architecture and Marine Engineering of Bangladesh University of Engineering and Technology (BUET) joined Islamic University of Technology (IUT) as Vice-Chancellor on 01 September 2020.

An overview of Export Oriented Shipbuilding of Bangladesh in the Context of IR 4.0

Dr. N. M. Golam Zakaria

As a maritime nation with 1,66,000 sq. km area of sea and more than 200 rivers all around the country, Bangladesh had a rich heritage of building timber ships since few hundred years back. Port city Chittagong was one of the best places for building timber commercial vessels and in the 15th century, Sultan of Turkey had built his fleet from this part. Also in 1805, British Navy built ships for the famous battle of Trafalgar at Chittagong. However, because of failure to keep pace with the evolvement of new technologies, glory of shipbuilding in this region began to fade away and shifted to other region of the world with the passage of time.

On the other hand, due to congenial geophysical condition, rivers and water transports have been playing a vital role for economic and commercial activities in Bangladesh. All the vessels plying in inland routes are mainly constructed and maintained by our indigenous shipbuilding and growth rate of inland fleet is quite amazing. As a result, Bangladesh has possessed a fleet of 20,000 vessels for its inland shipping within five decades of her independence.

This inbuilt ability and long-term heritage of the people in this region provide a strong base for building ships of international standard. Taking this opportunity, some local shipyard has been trying to make international standard ships since 2005. Lost glory has begun to revive when some local shipbuilders start to export ocean going vessels to foreign countries. Bangladesh has so far exported its product to companies in Germany, Denmark, Finland, New Zealand, Ecuador, Tanzania, Pakistan, Gambia, Uganda, India, Kenya and the UAE. The country can make a huge economic progress by properly nourishing and utilizing this export oriented shipbuilding industry. Entrepreneurs are also confident in the good prospect of flourishing shipbuilding industry in Bangladesh taking the advantages of its long history of maritime activity, favorable geographical location and availability of cheap work forces.

Export oriented shipbuilding is truly a global industry. It is also called a technological intensive, labor intensive and capital-intensive industry. Bangladeshi-made ships of international standard are roughly 10%-30% less costly than ships made in Japan, Korea, China and India. The main advantage with respect to our competitor is cheap labor. But this cheap labor alone cannot be the only factor for the sustainability of this industry in Bangladesh. Nowadays advance technology could bring cost savings and, in that case, we have a chance to lose our competitiveness if we only rely on labor cost. Therefore, for the development, expansion and long-term sustainability of this industry, numerous issues need to be addressed because the ultimate goal is to become competitive relative to other shipbuilding countries in the long run.

In the recent time, the impact of Industrial Revolution (IR) 4.0 on the worldwide industries has been discussed everywhere. It is known to all that the first industrial revolution introduced water and steam-powered mechanical manufacturing, the second industrial revolution brought electrically-

powered mass production system and the third industrial revolution introduced electronic and information technology (IT) for achieving further automation of manufacturing process. On the other hand, the current industry 4.0 leads to the complex use of digitization, combining the cyber world with the physical world by including internet of things, big data analytics, artificial intelligence, cloud computing, virtual and augmented reality, simulation, human-machine interaction, 3d printing, sensor technology, robotics, advanced devices, advanced materials technology etc. This industry 4.0 is poised to connect, integrate and automate everything on a grand scale: man, machine, materials, manufacturing process, products, logistics, customers–across the whole spectrum. This is also predicted to have unforeseen transformative effects not only on industry but also on every aspect of our human life.

The new industrial revolution wave in the shipbuilding sector is called Shipbuilding 4.0 and so, shipbuilding 4.0 is basically the follow up of the industry 4.0 concept applicable in shipbuilding industry. Industry 4.0 will definitely influence in the whole Maritime Sector and the transformation that will come in the shipbuilding industry is also believed to be very crucial. The main goal of shipbuilding 4.0 is intelligent shipyard which is characterized not only by adaptability, resource efficiency and ergonomic but also close integration among ship owner, shipbuilder, suppliers, the partners in the business and value processes. It is also believed that the changes that will bring by Shipbuilding 4.0 will be very different compared to the previous three industrial revolutions. Some shipyards that will fail to follow the changes will not survive and make profit. The modern shipbuilding industry that follows the revolutionary changes is expected to remain healthy in future, especially in the market segments of higher added value and with larger sales value. Almost all major players in shipbuilding industry are preparing themselves for the changes that will come in next 10 to 20 years, and strongly working on their own steps toward fourth industrial revolution.

Although shipbuilding is characterized by single units or small series production, still shipbuilding 4.0 raises the question of how the shipyards need to be changed to survive in the market. The Shipbuilding 4.0 promotes not only the digitization of the design and ship construction, but also requires further development of Process optimization, standardization, digital inter connectivity, optimization of information flow, interfacing the material management and information management within the entire supply chain. Full implementation is still a long away. Also, it is very unlikely that shipbuilding will go for full automation for the ship construction in future, but definitely more automation will come in future to cut production time, manual labor etc. The new machine based on advanced technology will come and shipyard needs a good infrastructure to work with man and machine. There may be change of supervision technique. Application of drones and automatic welding, will reduce risky job during the construction of ships.

In Shipbuilding 4.0 era, the shipyards need to have skilled engineers, specialists not only in technical science, but also in IT science. Engineers must have enough qualification to do all work done in a multidisciplinary environment using advance technology with interaction with machine while the ship is at her production stage. Also, in the design phase, it is very important to design innovative solutions together and in the closer cooperation with the selected suppliers. Designer needs to be minimized the design period as well as the engineering costs for future classes of ships. The IR 4.0 is definitely bringing changes in the world shipbuilding industry as well as other industries and many countries around the world are focusing on the advancement of technologies

to gain positive impacts from it. We need to acknowledge the facts and take necessary steps to embrace IR 4.0 especially for our promising export-oriented shipbuilding in Bangladesh. We must understand that only cheap labor cost may not be the major competitive factors in future for shipbuilding. We need to identify possible areas of improvement based on the scientific studies considering present industrial structure and future needs and requirements of shipbuilding. Govt. should come forward to support this industry so that it can improve its overall performances and become more competitive in the long run.

Author's Brief Biography

Dr. N. M. Golam Zakaria pursued his B.Sc and M.Sc in Naval Architecture and Marine Engineering from Bangladesh University of Engineering and Technology (BUET) in 1998 and 2002 respectively. He has completed his PhD from Yokohama National University, Japan in 2006. He joined NAME dept of BUET as a Lecturer in August 1999 and went through the rank of Professor in November 2012. He has been appointed as the Head of the department of Naval Architecture and Marine Engineering in BUET since February 2020. Dr. Zakaria's research arena includes sea keeping, stability , ship design , shipbuilding and green ship recycling.

Role of BIWTA and Future Prospects of Naval Architects

Commodore Golam Sadeq, (G), NGP, ndc, ncc, psc, BN,

Introduction

The use of waterways by mechanized vessels in Bangladesh began more than 150 years ago. Lord William Bentinck was the first inland steamer vessel that propelled in the river Ganges in 1834. The India General Navigation and Railway Company Ltd. (IGNR), the first inland steamer company was floated on February 6, 1844. During the latter part of the nineteenth century (1880-1899) as many as 898 vessels used to play the route from Calcutta to Khulna through the Sundarbans per annum. In the first quarter of the twentieth century the number rose to 4803.

During the Pakistan period eight principal operators were involved in organizing Inland Water Transport (IWT) operations. Those were (I) R.S.N. Company (II) I.G.N.R Company Ltd. (III) Pak-Bay Company (IV) B.R.S. Company Ltd. (V) Pak Flotilla. (VI) China Lighterage. (VII) Sinclair Murray and (VIII) E.B. Railway Flotilla. Both R.S.N. and I.G.N.R. were British companies with registered offices in London. Those two companies carried as much as 70% of cargo and passenger traffic. Water transport is the cheapest mode of transportation among others like road, railroad and air. Bangladesh is the most suitable place for water transportation. So Naval Architects have an important role to do something needful.

Creation of BIWTA

Bangladesh has about 24,000 km. of rivers, streams and canals that together cover about 7% of the country's surface. Most part of the country is linked with a complex network of waterways which reaches its extensive size in the monsoon period. Out of 24,000 km. of rivers, streams and canals only about 5,968 km. is navigable by mechanized vessels during monsoon period which shrinks to about 3,865km during dry period. The IWT sector carries over 50% of all arterial freight traffic and one quarter of all passenger traffic.

To set up authority for development, maintenance and control of inland water transport and of certain inland navigable waterways the then East Pakistan Government on 31st October 1958 promulgated an ordinance called the East Pakistan Inland Water Transport Authority (EPIWTA) Ordinance 1958. On November 4, 1958 the then Government by an order constituted a three-member Authority of East Pakistan Inland Water Transport Authority. The BIWTA came in to existence on promulgation of the above ordinance 1958 as the successor of the former EPIWTA.

Statutory Functions

BIWTA performs statutory functions of development, maintenance and regulatory nature. Some examples of development and maintenance functions are:

- Carry out river conservancy works including river training works for navigational purposes and for provision of aids to navigation including marks, buoys, lights and semaphore signals;

- Provided pilotage and hydrographic survey services;
- Draw up programmers of dredging requirements and priorities for efficient maintenance of existing navigable waterways and for resuscitation of dead or dying rivers, channels, or canals, including development of new channels and canals for navigation;
- Develop, maintain and operate inland river ports, landing/ferry ghats and terminal facilities in such ports or ghats;
- Carry out removal of wrecks and obstruction in inland navigable waterways;
- Conduct research in matters relating to Inland Water Transport including development of:
  - Craft design;
  - Technique of towage;
  - Landing and terminal facilities;
  - Port installations.

- Maintain liaison with the Government and facilitate import of repair materials for the Inland Water Transport Industry
- and many mores.

Regulatory Functions

Some Regulatory Functions of BIWTA are worth mentioning, such as:

- Fixation of maximum and minimum fares and freight rates for Inland Water Transport (IWT) on behalf of the Government;
- Approve time tables for passenger launch services;
- Inspection of cargo and inland vessel to ensure compliance with the provision of ISO -1976;
- Act as the competent authority of Bangladesh for the protocol on Inland Water Transit and Trade (IWTT);
- and many more.

Recently Complete and Ongoing Projects

- Procurement of 10 dredgers, crane boats, tugs, officer house boats and crew house boats with other accessories;
- Capital Dredging of 53 river routes in inland waterways;
- Procurement of 20 Dredgers with Ancillary Equipment and Accessories;
- Modernization of three DGPS Beacon Stations including Control Station & Monitoring Station;
- Improvement of navigability from Mongla to Pakshi river route via Chandpur-Mawa Gualanda;
- Procurement of 35 Dredgers with Ancillary Equipment and Accessories.
- and many others.

Role of BIWTA in Prospects of Naval Architects

BIWTA is one of the core platforms for Naval Architects in Bangladesh. Being the authority of Bangladesh inland water transportation system, BIWTA and the Naval Architects of this country can be said counterpart of each other. BIWTA is striving for a modernized and sustainable inland water transportation system which in turn will ensure the prospects of Naval Architects of this country. Naval Architects are performing the sole responsibility in various parts of BIWTA. Besides performing as Chief Engineer in two different vital departments, Naval Architects are holding various important posts in this authority. A TO&E of comprising a number of Naval Architects has already been approved by the current government which is now in implementing stage. Most project of this authority cannot be implemented without the Naval Architectural knowledge. We all know that the current government has taken initiative to implement a number of huge size projects to take our beloved country at the zenith of development. BIWTA is also a proud part of this development work where Naval Architects are taking part very closely. But of course, BIWTA is not going to stop here. BIWTA will continue to develop safest and technically sound inland vessel design, integrated management system for river routes and departure/arrival of vessels for ensuring the utmost comfort of the users.

The prospects of any field or nation depend on the challenges. It is the enthusiasm of facing challenges which can only assure the future prospect. Challenges are nothing but scope of prospects. In this regard the main challenges of BIWTA in relation of Naval Architecture and Marine Engineering are discussed here. Maintaining the inland water channel is the biggest challenge for this authority as we all are well aware about the siltation rate in our river beds. Bangladesh is a country which covers approximately 60% of the largest river delta of the world. Our river channels are also geometrically restricted. This restriction along with the less water depth also govern the inland vessels dimension which makes our local vessels fleet unique and different from the other riverine nationals of the world. The special features of Bangladesh inland waterways can be summarized by shallow water, restricted water channel, socio – economic condition, sudden seasonal storm, unpredicted weather condition etc. The current statutory rules for inland vessels of our country are still not equitable. Inland vessel accident is a persistent phenomenon in Bangladesh inland waterways. We have observed some terrible collision in our inland navigation very recently. Accidents of country boats are also happening very frequently. Thousands of people have passed away due to these catastrophic incidents. The heterogeneity of parameters governing the statutory rules for designing and building safe and comfortable inland vessel demands individual efforts of countries. These are some of the challenges that are worth mentioning. The Naval Architects need to face and resolves these challenges. In this perspective BIWTA has established a 'Design and Monitoring Department' and I believe this is going to be an excellent platform where research and development work can be carried out to impart the best possible solutions of the mentioned challenges. I also believe that all the academic institutes that produce Naval Architects will continue and extend their support to BIWTA for performing and implementing the responsibilities and duties that are assigned to BIWTA by the government. However, only by working and sticking together the prospect of Naval Architects can be ensured in future. So, undoubtedly Naval Architects will have to play a vital role to develop IWT which can bring to them vivid future.

Author's Brief Biography

Commodore Golam Sadeq (G), NGP, ndc, ncc, psc, BN commisioned on 1st July 1989 in Bangladesh Navy. He received naval training from the Royal Malaysian Navy. Commodore Sadeq commanded various naval ships and base like Missile Boat, Patrol Craft, Mine Sweeper, Offshore Patrol Vessel, Frigates and various bases of Bangladesh Navy. He led three training base namely BNS SHAHEED MOAZZAM, BNS ISSA KHAN and Bangladesh Naval Academy. Besides, he discharged his duties as staff officer and Director in Naval Headquarters. He annexed his academic excellence through higher degrees from Royal Navy of the UK, Mirpur Staff College, Naval War College of the USA and National Defense College of Bangladesh.

He achieved peace medal and naval award medal in the year 2014 for his remarkable contributions in various operations and training activities of Bangladesh Navy. Commodore Sadeq presently serving as Chairman BIWTA.

Transformation of Job Sector in Shipping in 4th Industrial Revolution: Reshaping the Maritime Education and Training of Bangladesh

Capt Sabbir Mahmood

Introduction

Shipping is the lifeblood of global economy and international trade. The technology was placed at the center of the strategy since inception of shipping and observed the first crack of impact during each previous IRs. Similarly, there will be huge impact on maritime industry during 4th IR as the future ships will be controlled by complex automated systems. The technology will gradually reduce the number of seafarers on board which may further result in unmanned ship.

As such it is timely to conduct research on how the job sector of the shipping industry will be transformed during 4th IR and what type of reformation in MET will be required to ride on the wave of new era. The study is based on empirical research to find out the outcomes through using quantitative and qualitative data collection methods. The data has been collected from focus group those are working on board and at shipping companies of Bangladesh.

Transformation of working environment on board in 4th IR

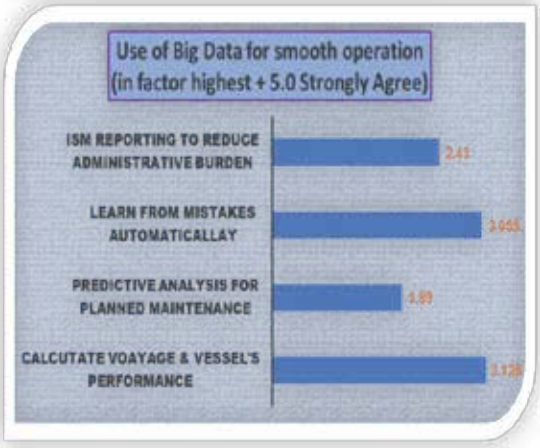
The 4th IR is expected to reach at peak around the middle of the twenty first century and bring disruptive changes by exploring and implementing new technology in all spheres to create a safer, efficient, and greener solution. The technologies like Robotics, Artificial Intelligence (AI), Machine Learning, IoT, Blockchain, Drones, and Augmented Reality (AR) are being harnessed to shake up the job sectors of maritime industry.

Smart ship is the final outcome of the fast-approaching 4th IR which will take long years but the process has been sparked. There are three stages to achieve the final goal of 4th IR which are manned with skeleton crew, unmanned but remotely controlled and fully autonomous unmanned ship where human operator is replaced by artificial intelligence and software control (Kobylinski, 2016). The IoT will help to monitor the navigation, machinery, cargo, safety, hull integrity and weather condition in real time from ashore by collecting enormous amount of data. The big data will provide competitive advantage in modern shipping with reduced job pressure on board. A number of shipping companies have started using management solutions covering technical, procurement, hull integrity, dry docking, QHSE, crewing, and fuel optimizing.

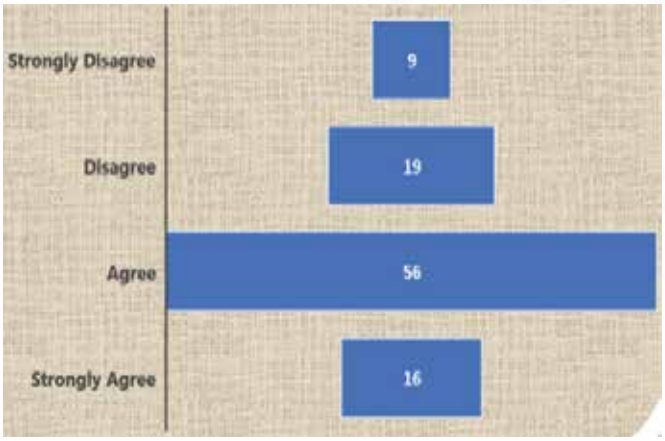
At present robots are being used for inspection, cleaning and maintaining the ship's hull and ballast tanks in zero visibility, curved area and without damaging the environment. (Noordstrand, 2018). The autonomous humanoid robot is capable of detecting and extinguishing fires on board and working side by side with human firefighters using advanced technology. Augmented reality (AR) technology has great potential to help in maintenance, remote assistance, and for training purposes including improving situational awareness among seafarers. AR technology is also being

used to inspect ship and machinery remotely by surveyor and experts to ascertain the condition and suggest accordingly.

From our survey it has been revealed that big data and IoT will reduce the administrative burden of seafarers. The AI will help the seafarer to learn and make decisions from earlier mistakes including conducting predictive maintenance. The respondents have shown their agreement in favor of statement that, Robots, Drones and AR will make the seafarers job safer and easier in near future.



Big Data will reduce work pressure of seafarer



Robots, Drones & AI will make safer ships

Figure 1 Survey data findings

Transformation of job sector in shipping in 4th IR

There are 1.6 million of seafarers that keep the world moving and make vital contributions in international trade. The contribution of seafarers is indispensable in global economy but presently automation and new technologies are exerting pressure on the job market of seafarers and other transport workers in maritime sector. For instance, during earlier transformation the number of seafarers reduced by 85% in last 100 years (Sintef, 2020). It is expected that, the introduction of smart ships can reduce the global demand for seafarers by 22 per cent within 2040 (ITF-WMU, 2018).

As the current "digitalization" of the conventional fleet proceeds apace, the tasks of seafarers will change to more digital ones, especially in monitoring and system management instead of operational work. Despite of fully autonomous unmanned vessel the demand of seafarer will not completely disappear, but the seafarers' skills need to be integrated with digital skills which are data fluency, ability to interpret and analyze large amounts of data. The mid-level jobs will be affected more but there will some high-level newly created jobs in maritime sector, such as ship automation specialist, cyber security specialist, 3D printing technician, energy efficiency optimization specialist, predictive data analyst and data protection specialist (Andi Reni et al, 2020). According to the research findings, the ship automation specialist is the most lucrative profession for seafarer with 28% response and second contemplated job is cyber security and energy efficiency specialist with 21% response.

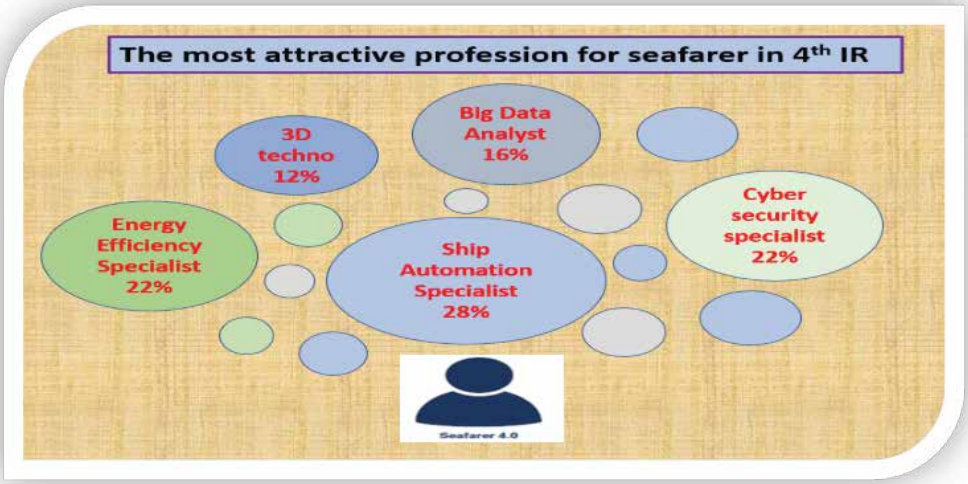


Figure 2 Profession for seafarer in 4th IR

MET to adopt with disruptive changes in 4th IR in Bangladesh

According to the World Bank report, Bangladesh is among the five fastest growing economies of the world, in terms of high GDP growth which provides a good opportunity to gain a strong foothold in world maritime sector. At present Bangladesh is owning 78 nos of foreign going ship of total about 360000 MT deadweight and the trend of ship owning is growing in last few years. The sustainable development of Bangladesh shipping will be achieved by focusing on complete reorganization of business model through innovative ideas, technological solution and digital management system under the synergies of 4th IR but which is literally impossible without developing the appropriate human resource through transformation of Maritime Education and Training (MET) sector in Bangladesh.

One of the transformative leaders in Bangladesh shipping stated that, "We have strategic vision to adopt with disruptive changes in 4th IR but the main obstacle in this transformation is less inspiration and motivation of employee due to fear of losing job, unawareness and rigidity in old style of work". However, to overcome the above situation following measures may be adopted by maritime administration, shipowners and MET institute:

- The MET institute must reinvent themselves quickly and adapt the demands of the IR4 and have the obligation to come out of its shell. The strategies, contexts and learning process in the MET institutions to be prepared to enhance the skills of the students to prepare themselves for future job.
- The complexity of the systems developed to meet the demands of the fourth industrial revolution necessitate interdisciplinary and industry-institute collaboration.
- Under industry 4.0, in addition to technical competences, seafarers must be good at a variety of soft skills. These skills cannot be achieved through separate subjects but gradually developed via learning process. Following are the key skill to be developed among future seafarers.

Communication & Co-ordinating	Adaptability & cognitive flexibility
Digital proficiency	Innovation & Creativity
Critical Thinking	Emotional intelligence
Technical skills	Self-learning
Data-based decision	People Management & Negotiation
Complex Problem-solving	Service Orientation

- ❒ Developing e-learning platform and on-line courses & make them available to the seafarers on board.
- ❒ Expansion of teacher development programme.
- ❒ Redefining the strategic plan not only to reform but also to keep on developing the curriculum, learning process to give more room for creativity and find new solutions.

Conclusion

Based on a systematic literature review and empirical research this article provides an overview of the current state of digitization in maritime logistics and discusses the changing environment of job sector in shipping. The human factor is always at the center of attention as seafarers' job will be transformed into various digital specialist job including phasing out of low and mid-level job. The MET institution is to prepare their cadets for the future which is uncertain with increasingly intelligent machines. As such they have to keep radically changing the teaching and learning methods instead of simply reforming current education systems. To enhance the emerging skills like creativity which is almost neglected in present shipping management the MET should encourage the learners' independence, critical thinking, problem solving and application of knowledge. The final outcome of the study is, the MET institute has no choice but to adopt disruptive changes quickly in 4th IR and if they fail to ride on the wave will have to face disappearance form the business.

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Author's Brief Biography

Captain Sabbir Mahmood was a former Principal Surveyor at Henderson International and former Master of Dredger, MV Khanak. Capt. Mahmood had completed his masters in World Maritime Science: Ocean Sustainability, Governance and Management from World Maritime University and achieved an advanced certificate in Business administration and management from the University of Dhaka. He has also been awarded an LLM in Maritime Law from London Metropolitan University.

Story of Safer Cruise Ship for 21st Century

Commodore Khandakar Akhter Hossain, (E), psc, NUP, PhD, BN

Abstract

A passenger ship is a merchant ship whose primary function is to carry passengers on the sea. The category does not include cargo vessels which have accommodations for limited numbers of passengers, such as the omnipresent twelve-passenger freighters once common on the seas in which the transport of passengers is secondary to the wagon of freight. Now ocean liners and in virtually all cruise ships cargo capacity has been eliminated. Cruise ships are large passenger ships offering pleasure trips adventure seeking people in modern time. They have onboard facilities of restaurants, bars, casinos, theaters, ball rooms, discos, swimming pools, fitness center, and shops that make them a complete and safe floating resort. It is a review article which briefly narrates the story of safer cruise ship for 21st century with its history, business, design, construction, technology, safety and recycling process.

Keyword

Passenger liner, Azipod, Eco-ship, Peace Boat, etc.

Introduction

Passenger liner end up their journey in the 1970s and resurrection of the cruise ship in sea travel rise up incredibly. Before Covid-19 pandemic, around 25 million passengers annually travelled globally. The size and luxury of the cruise ship is the key factors when a person decides how to spend his or her vacation. During the years, the cruise ship industry has been developed dramatically due to its major part in the tourism industry. The tendency is building larger than the biggest cruise ship. Actually, the giant size comes with more features, more opportunity, and more luxury for entertainment, enjoyment and lower prices. The idea of a cruise ship transforms in time and the ship industry tries to answer the demands[1]. Two giant and extreme luxury cruise ship Oasis of the Seas[2] and Harmony of the Seas[3] have been shown in fig 1 below. There are eighteen decks in Oasis of the seas, where machinery spaces cover under water three decks. Cruise details, amenities and services including accommodations, floor plans, photos, cabins or suites sizes, types and categories, furniture and other necessary detailed information of Oasis of the Seas could be collected from the Royal Caribbean website[4]. Cabin 3D design is also available in the website[5 6]. It is really surprise to anybody that, unlike our standard-issue skyscraper or mega-resort, a cruise ship is not built from the ground up[7]. Actually pieces of the ship are built off-site and then hoisted in Tetris-style by a giant gantry crane. However, these prefab pieces can be as big as four decks in height and span one-half of the ship's width.

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[1]http://www.vesseltracking.net/article/biggest-cruise-ships]

[2]https://depositphotos.com/stock-photos/oasis-of-the-seas.htm, Retrieved 6 Feb 2020. oasis-of-the-seas

[3]https://cruisedeals.expert/royal-caribbean-harmony-of-the-seas, Retrieved 26 Oct 2020. harmony-of-the-seas

[4]https://www.cruisemapper.com/cruise-lines/Royal-Caribbean-1, Retrieved 26 Oct 2020.

[5]https://www.cruisemapper.com/cabins, Retrieved 26 Oct 2019.

[6]https://www.royalcaribbean.com/cruise-ships/oasis-of-the-seas/rooms, Retrieved 26 Oct 2019.

[7]https://www.ontraveler.com/story/cruise-prices-are-dropping-this-year, Retrieved 12 Oct 2019.

In a typical resort, the pool is at ground level, while restaurants are at most, on the second or third floor, and theaters are housed in their own buildings. On a cruise ship, though pools are stacked on the highest decks for sun exposure; while theaters are located towards the front or back, since we can't pass through them. Cabin and staterooms arrangement are such that, anybody can delightfully be sleeping in his room. Dance floors are raised to accommodate an added layer of acoustical absorption; all speakers are hugged by a sound-absorbing material; carpeting is an absolute must; walls are padded in the prettiest sound-absorbing fabrics a designer can find; and nearly every inch of ceiling is clad in perforated acoustical tiles[8]. Electrical and firefighting equipment usually needs to be totally concealed to facilitate elaborate network of plumbing. Designers' battle with shipbuilders and engineers to introduce coffers, mirrors, brightly lit ceiling coves and false skylights that offer an illusion of higher ceilings, especially in larger rooms. But for some designers, giving spaces in cruise ships the illusion of height starts at the walls. The mega cruise ships and their fantastic looks can be seen from fig 1 below .

Fig 1: Mega cruise ships and their fantastic looks

The actual cruise shipbuilding takes 2 to 3 years. However, the design plans are usually started a year ahead for safer ship. Shipbuilding takes place in specialized facilities known as dockyards or shipyards. The cruise ship hull is designed by the shipyard with their own naval architect, while the interiors and all the special features are designed by both general and naval architect. Shipbuilders do shipbuilding, as well as ship repairs, both services being also referred to as naval engineering[10]. The reverse process (dismantling of ships) is called ship breaking or recycling. The world's biggest ship breaking scrap yards are in India (Alang), Bangladesh (Chittagong), Pakistan (Gadani) and Turkey (Aliaga). It is a review article which briefly narrates the story of cruise ships with imaging description of history, feature, business, design, construction, stability, technology, safety, demolition, etc.

[8]https://www.ontraveler.com/story/cruise-prices-are-dropping-this-year, Retrieved 11 Oct 2019.
[9]http://www.vesseltracking.net/article/biggest-cruise-ships, Retrieved 11 Oct 2019.
[10]https://www.researchgate.net/publication/264068444_A_Study_for_Recent_Cruise_Ship_Design_and_Construction_Trends, Retrieved 13 Nov 2019.

History of the Cruise Industry

Until the 1960s, the passenger ships carried crowds of passengers from one destination to the other. When the wind blew in the industry's sails and modern cruising as we see it today took form. In the middle of 19th century, the main passengers' ship purpose was transferring people across the Atlantic. The then biggest cruise ship had amenities like onboard electricity; there was no luxury and other facilities for safer ship. The first cruise ever in the history has often been stated to be the two-month Augusta Victoria voyage in the Near East and the Mediterranean in 1891. The first biggest cruise ship had a capacity of 241 passengers came in 190 and that was exclusively built for cruising. Her name was Prinzessin Victoria Luise. The general manager of Hamburg-America Line, Mr. Albert Ballin, designed the ship. It was the biggest cruise ship with overall length of 124 m in that time. The first biggest cruise ship Prinzessin Victoria Luise has been shown in fig 2 below. The safer cruise ship design and construction is always challenge.

Fig 2: The first biggest cruise ship Prinzessin Victoria Luise and a delighted night view of a modern Cruise ship[11] [12].

The story of RMS Titanic was really exciting. The shipping industry noticed that a transatlantic crossing was four-day-long at least. The companies tried to attract more passengers by adding different luxuries. This was the era of RMS Titanic. She was the biggest cruise ship in 1912. She was built by Harland & Wolff with length of 269.06 m and cost USD 7.5 or £1.5 million. RMS Titanic sank after a tragic accident on her maiden voyage. In the early 30s of the 20th century Adolf Hitler, the Nazi leader helped the developing of the cruising industry. He tried to unite the nation by giving holiday packages to German workers. The comparison between RMS Titanic and the Allure of the Seas has been shown in fig 3 below. Turning point for the cruise industry was the 1960s advent of large passenger jet aircraft. The people replaced the ships with planes for transportation. The ocean liners started declining slowly while the cruising voyages increased their popularity. Major success in the 1980s was the change of SS France, ocean liner. Converted to the then biggest cruise ship SS Norway[13]. The record for the biggest cruise ship was held by Norway for a long time. Their era ended in the late 1980s with the beginning of the Sovereign-class. They were the pioneers to include glass elevators and multi-story atrium. They were at the top of the biggest cruise ship ranking and since the beginning of the 21st century, the ship industry adds at least nine cruise ships every year. The recent

[11]https://www.google.com/search?q=cruise+ship+Prinzessin+Victoria+Luise&rlz=1C1UEAD, Retrieved 18 Oct 2020.
[12]https://en.wikipedia.org/wiki/Prinzessin_Victoria_Luise#/media/File:Prinzessin_Victoria_Luise, Retrieved 11 Oct 2020.
[13]https://www.google.com/search?q=cruise+ship+SS+Norway+&tbm=isch&ved, Retrieved 18 May 2021.

past biggest cruise liner RMS Queen Mary 2 built in 2004[14].It replaced the retired Queen Elizabeth 2 and stayed the largest passengers' ship until the launch of the Royal Caribbean International Freedom Class in 2006. Those vessels were occupying the first places in the biggest cruise ship ranking until the debut of the current leaders the Oasis-class. The competition of building the most exiting cruise ship in the world continues and the title "biggest cruise ship" is very attractive to every company. The recent innovation step is the Quantum of the Seas. It is now the biggest cruise ship in the world. Quantum is sailing with amenities like the revolutionary skydiving simulator Ripcord by iFly and Family-Connected staterooms[15]. The Symphony of the Seas the biggest mega cruise ship in the Caribbean and has been shown in fig 4 below.

Cruise ship overall length, breadth, gross tonnage and capacity are the main consideration for the ranking of the biggest cruise ship. The biggest top 12 cruise ship with their amazing features has been shown in table 1 below. A comparison between RMS Titanic and the Allure of the Seas has been shown in fig 5 below. Now cruise lines is a global business and it has around USD 120 billion in economic impact as per Cruise Lines International Association (CLIA) report published in 2014. It's providing around USD 39 billion in global wages. At the same time, it also creates around one million jobs around the world. A video link of the 10 biggest cruise ships has been given below [16].

Fig 3: The images of SS Norway, the first super-ship and the Symphony of the Seas, the biggest mega cruise ship13[17].

[14]https://res.cloudinary.com/gangwaze-res/image/upload/c_scale,f_auto,w, Retrieved 11 August 2020.
[15]https://www.google.com/search?q=cruise+ship+Quantum+of+the+seas&tbm=isch&ved, Retrieved 15 Oct 2020.
[16]https://www.youtube.com/watch?v=ylGFWEHHlpk. Retrieved 19 June 2021.
[17]https://res.cloudinary.com/gangwaze-res/image/upload/c_scale,f_auto,w, Retrieved 22 April 2020.

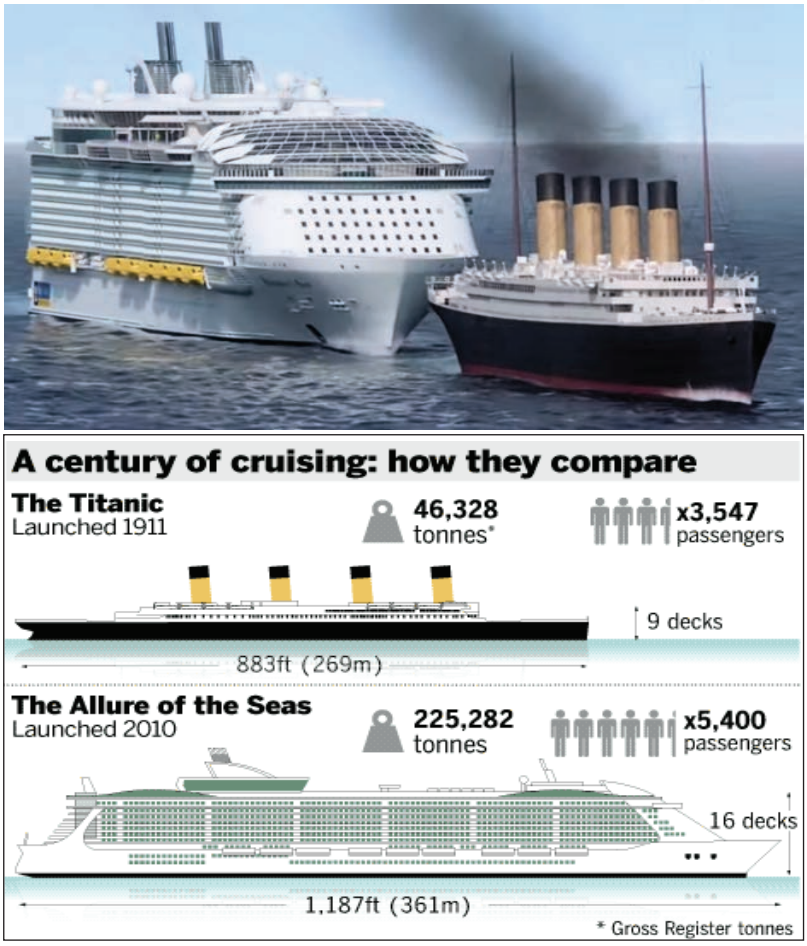

Fig 4: The comparison between RMS Titanic and the Allure of the Seas[18]

Table 1: Top 12 giant cruise ship and their important information.

No	Name	Line	Year	Gross Tonnage	Length	Capacity
1	Symphony of the Seas		2018	228000	362 m	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 m	5660

[18]http://www.vesseltracking.net/wp-content/uploads/2016/05/Biggest-Cruise-Ship-Titanic-vs-Allure.gif, Retrieved 16 Feb 2021.

No	Name	Line	Year	Gross Tonnage	Length	Capacity
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

Cruise Ships Facilities

Cruise ships require electrical power and that is usually provided by diesel generators. Nowadays new cruise ships are fueled by Liquefied Natural Gas (LNG). When docked, ships must run their generators continuously to power on-board facilities, unless they are capable of using onshore power. Statistics says polluting emissions from the diesel generator can be equivalent to 700 trucks running their engines and is harmful where ships dock in populated areas. Modern cruise ships typically have very wide range of facilities, like: Casino, Shops, mall, Spa, sports center, Fitness center, Library, Theatre with Broadway-style shows, Cinema, Cineplex, Card room, Infirmary and morgue, Ping pong tables, laundry, Clubs, Lounges, Buffet restaurant, Hot tub, Observation lounge, Karaoke, Teen Lounges, Child care facilities, Indoor and/or outdoor swimming pool with water slides, etc. Few cruise ships have bowling alleys, ice skating rinks, rock climbing walls, sky-diving simulators, miniature golf courses, video arcades, zip-lines, surfing simulators, basketball courts, tennis courts, chain restaurants, ropes obstacle courses, and even roller coasters. Two video links of top 10 most luxurious cruise ships in the world has been given below[19].

A very few people travel to the faraway land annually that is known as the White Continent. Those who do, typically arrive by cruise ship, with a small-group experience of just up to 200 fellow adventurers at a time on these highly seaworthy vessels. If we head down to the southernmost part of the world, we'll find a quiet and scenic region that is home to creatures that thrive in icebound conditions amid rugged and beautiful landscapes. Cruises to Antarctica are growing in popularity

[19]http://www.vesseltracking.net/wp-content/uploads/2016/05/Biggest-Cruise-Ship-Titanic-vs-Allure.gif, Retrieved 16 Feb 2021.

nowadays. Dozens of new specialty expedition ships have been built or are launching in the coming years and many of these vessels will offer itineraries to the polar regions of the Arctic and Antarctica. More than 55000 people travel to Antarctica each year, with most coming from North America. Out fitting and Galley of a modern cruise ships have been shown in fig 6 below. Cabin Arrangement of a modern cruise ship has been shown in fig 7. Swimming pool and theater arrangement of a modern cruise ship have been shown in fig 8. Ice Skating and games facility of a modern cruise ships have been shown in fig 9 below[20].

Fig 6: Out fitting, Galley, dinning, etc. of a modern cruise ship.

Fig 7: Cabin Arrangement of a modern cruise ship

[20]https://www.google.com/search?q=images+of+sketting+games+in+cruise+ship&tbm, Retrieved 7 Feb 2020.

Fig 8: Swimming pool and theater arrangement of a modern cruise ship.

Fig 9: Ice Skating and games of a modern cruise ship.

Cruise Ship Stability

Today's cruise ships are very gigantic, but remain stable due to their reasonably low center of mass. This is due to 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 fig 10 below[21]. However, most cruise ships utilize stabilizers to reduce rolling in heavy weather and fin stabilizer has also been shown in fig 10 below. But it is only used for crew and passenger comfort. It not contributes to the overall intact stability of the ship. Interesting to know that, cruises are getting safer over time. The video link of top 10 biggest cruise ships crashes and collision at terrible monster waves in storm has been given[22] below. The accident and sinking of cruise ships of Costa Concordia and Titanic has been shown in fig 11[23].

[21]https://www.google.com/search?q=stability+of+a+modern+cruise+ship+images, Retrieved 27 August 2020.
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[23]https://www.google.com/imgres?imgurl=https%3A%2F%2Fi.insider.com and
https://www.google.com/search?q=titanic+accident++images&tbm, Retrieved 8 Feb 2021.

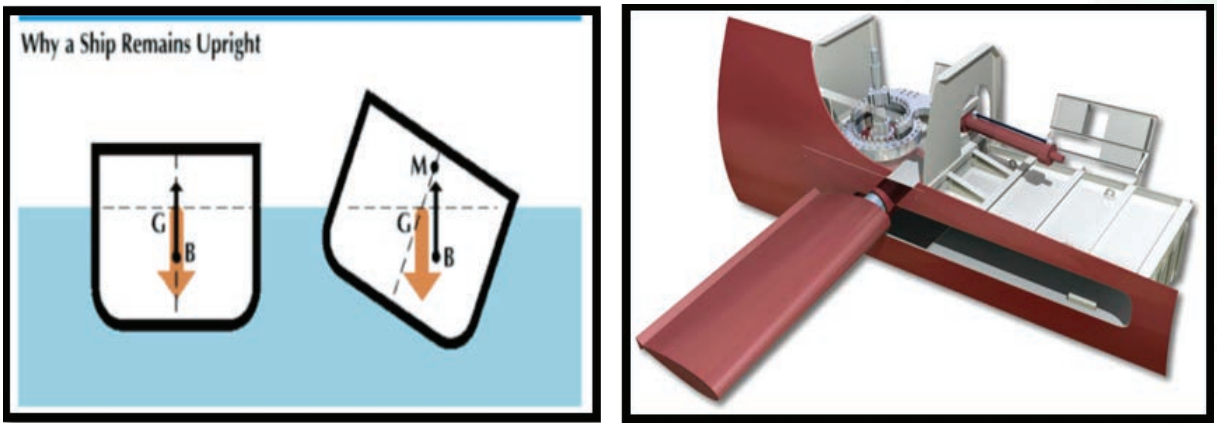


Fig 10: Ships stability with upright condition and fin stabilizer[21].

Fig 11: Accident and sinking of cruise ships of Costa Concordia and Titanic[23].

Cruise Ship Crew

Cruise ship crews are usually hired on three to six-month contracts and that may be renewed as further, as and when required with mutual agreement. A crew and staff usually work 77-hour work weeks for 10 months continuously and followed by two months of holiday. Non-service and management crew members get paid vacation, medical, retirement options, and can participate in the company's group insurance plan. Crew and staff do not have any expenses while on board, because food and accommodation, medical care, and transportation for most employees, are included. There are few crewing agencies who often exploit the desperation of potential employees. In cruise ship usually two employees share a cabin with a shower, commode and a desk with a television set, while senior officers are assigned single cabins. There is a set of facilities for the crew and staff separate from that for passengers, such as mess rooms and bars, recreation rooms, prayer rooms or mosques and fitness center, a crew deck with a swimming pool, so on. All crew members are required to bring their certificates for the Standard of training, certification and watch keeping while being on board. All renowned cruise operators, most hotel staffs are hired from less industrialized countries in Asia, Eastern Europe, the Caribbean, and Central America. The International Labor Organization or ILO sets precise standards regarding hours of work and rest, health and safety, and living conditions for crew members, and requires governments to ensure that ships comply. Staff and Crew of a modern cruise ship have been shown in fig 12 below[24].

[24]https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.azamara.co.uk and https://www.google.com/imgres?imgurl=https%3A%2F%2Fimage.slidesharecdn.com, Retrieved 3 Dec 2020.

Fig 12: Staff and Crew of a modern cruise ship[24].

Global Cruise Lines Business

CLIA's 2014 economic impact analysis, which was an independent study commissioned by CLIA and conducted by Business Research and Economic Advisors (BREA), has been shown that total contributions of the cruise industry to the global economy reached USD 119.9 billion in 2014, up from USD 117 billion from 2013. This includes supporting 9,39,232 full-time equivalent employees earning USD 39.3 billion in income. However, the direct expenditures generated by cruise lines, passengers and crews totaled USD 55.8 billion[25]. Again CLIA's 2014 Asia Cruise Trends Study shows that cruise tourism in Asia is growing at double-digit rates, both in capacity and as a passenger source market. Between 2013 and 2015, the number of ships deployed in Asia grew at a 10 percent compound annual growth rate, and the volume of cruises and voyages within and through Asia increased 11 percent. Passenger capacity in Asia increased 20 percent.

Most cruise lines since 2000s have to some extent priced the cruising experience as passenger spending aboard generates significantly more than ticket sales. Again, the passenger's ticket includes the stateroom accommodation, room service, unlimited meals in the main dining room or restaurant and buffet, access to shows and use of pool and gym facilities, while there is a daily gratuity charge to cover housekeeping and waiter service. However, there are extra charges for alcohol and soft drinks, official cruise photos, Internet and wifi access, casino and specialty

[25]https://www.offshore-energy.biz/clia-cruise-passengers-top-22-million-mark-in-2014 , Retrieved 27 Mar 2021.

restaurants. Cruise lines earn significantly from selling onshore excursions offered by local contractors; keeping 50% or more of what passengers spend for these tours. In addition, cruise ships earn significant commissions on sales from onshore stores that are promoted on board as much as 40% of gross sales. Ports of call have often oriented their own businesses and facilities towards meeting the needs of visiting cruise ships. Travel to and from the port of departure is usually the passengers' responsibility, although purchasing a transfer pass from the cruise line for the trip between the airport and cruise terminal will guarantee that the ship will not leave until the passenger is aboard[26]. Few luxury cruise lines market their fares as all-inclusive. The fare may also include a one-night hotel stay before boarding and the air fare to and from the cruise's origin and destination ports.

Cruise Ship Construction and Design

The safer cruise ship design is always a great challenge. Let's consider a modern cruise ship with 4000 passengers and crew. The water consumption of such ship will be 12,00,000 liters per day or 1200 tones as considering about 300 liters per person per day. Again, the requirement of power of same cruise ship to keep everything working is about 12 MW and that is enough for a town of 27000 homes. The amount of solid waste of same cruise ship is 6 tons per day as considering about 15 kg of solid waste per person a day. Again, the amount of food waste is 2 tons per day as considering about o.5 kg of food waste per person a day. The amount of sewage is 100 m^3 tons a day as considering about 25 liters of sewage per person a day. The rest of the water ends up as waste water to be treated as required.

Now a day's cruising is not boring. Spending time on a mega size cruise ship is really interesting. Hollywood immersion cruise and dinner with a Marilyn Monroe or Michel Jackson look alike, anyone? Murder mystery, music, yoga or cooking and wine tasting voyages? Gyms, jogging tracks and spas are on board many mega cruise ship and so are exercise areas, raw cooking, healthy diets and what not? Study says that, a tourist can see up to eight destinations on a nine-day European river cruise. This is twice the number that the tourist would be able to visit on a land tour. Statistics says that, minimum 12500 plates, 10000 glasses and 15000 items of cutlery need to be washed on a ordinary cruise ship every day. There are more than 2000 ports that cruise ships can visit around the world. Carnival Cruise Line alone places more than 10 million chocolates on passenger pillows every year. Allure of the Seas is five times bigger than the Titanic, weighing 225282-tonnes and carrying 6296-passengers compared to Titanic's 1343. The Silver-sea Cruises' "Silver Whisper" could cost upwards of $1.5 million per couple with a helicopter ride, and a 10-course Michelin star meal while aboard a private jet then over 4 months visiting 28 destinations26.

Cruise ship construction

The safer cruise ship construction is always a challenge. Actually, a cruise ship building process involves numerous complex researches and testing procedures. The cruise ship design company and their work are known as naval architecture; analyses and provides solutions to meet the marine and shipbuilding industry's requirements. This huge and complicated task usually started with submitting the basic and detailed designs, ship equipment designs and technical and production drawings to the shipbuilding company. The design firm also provides naval architects, engineers

[26]https://cruisepassenger.com.au/20-things-you-didnt-know-about-cruising, Retrieved 9 Jun 2021.

with analysis, simulations, diagnosis, manufacture, repair and other data by using the latest CAE (Computer Aided Engineering) technology[27 28]. The ship cabins manufacturer is able to design and produce various types of ready-to-install ship cabins and bathrooms for virtually all passengers and cruise ships; like big and small, luxury, ferries, Ro-Ro, research, etc. The ship builder also hires a company to provide the so-called Lifecycle Services, pertaining mostly to the industry's rules and regulations. Some of these services are retrofitting and refurbishing and keeping regular updates regarding new and international rules and requirements[29].

It's a common modern practice that, big cruise ships to be built of pre-made huge sections. Entire multi-deck segments are built at another place, transported or slipway to the shipyard and lifted into erection place. That is usually known as block or modular construction and which is shown in fig 13 below. The sections often feature even pre-installed equipment, cables, pipes and other components. Actually, it saves a lot of shipbuilding time and it certainly saves lots of money. This technique was used for the first time in the construction of the Queen Mary 2 ship (2002-2004) by the French "Chantiers de l Atlantique" company. 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 links has been given in reference[30].

Fig 13: Block or modular construction

Cruise Ship Design Philosophy

Naval architecture and marine design solutions for cruise ships are truly amazing and unique. It 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,

[27]https://www.napa.fi/software-and-services/ship-design/hull-form-design-and-hydrodynamics, Retrieved 27 Nov 2020. Design and hull form

[28]https://www.cruisemapper.com/wiki/757-cruise-ship-building-construction-design, Retrieved 17 August 2020. Design and construction

[29]https://www.besthospitalitydegrees.com/10-most-incredible-cruise-ship-designs, Retrieved 11 August 2019.

[30]https://www.youtube.com/watch?v=v8nI2Ct58cU and https://www.youtube.com/watch?v=hBsT8J2dFIE, Retrieved 7 Feb 2021.

numerous bars and lounges, and all new big ships feature an open around-ship Promenade[31] 28. 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. Cruise ship construction in a dry dock and structural arrangement of a cruise ship has been shown below in fig 14[32]. Wonderful view of two modern cruise ships has been shown in fig 15 below[33].

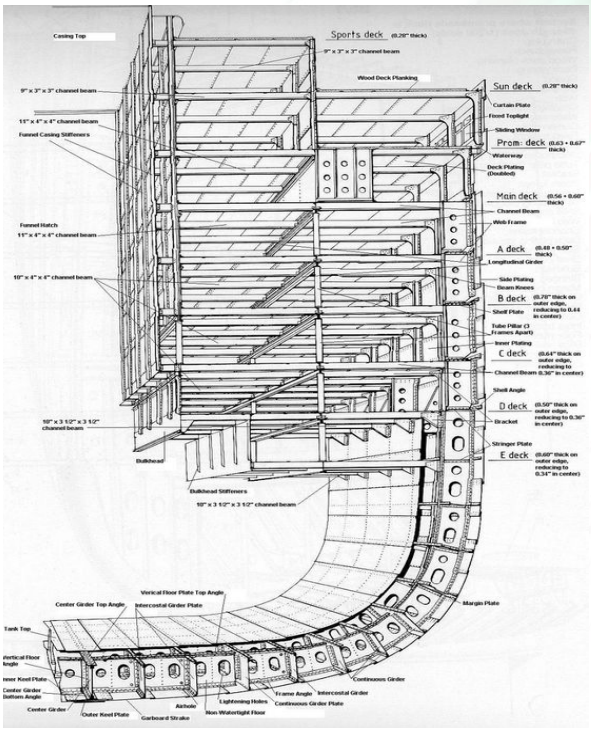


Fig 14: Cruise ship construction in a floating dock and structural arrangement of a cruise ship.

Fig 15: Allure and Harmony of the Seas.

Cruise Ship Engine, Power and Propulsion System

The choice of safer and environment friendly cruise ship propulsion and machinery system is always challenge. Modern cruise in 21st century ship has some interesting technology, data and facts. Such as: engines, power, marine propulsion systems, fuel consumption, safety and environment pollution. In 2020, IMO (International Maritime Organization) implements its global 0.5% sulfur cap on marine fuels. If ship not using scrubbers (pollution control devices), owners of older vessels must use as ship fuels MGO (marine gas oil), ECA Category Fuels (low sulfur MGO), new modified fuels and blends, LNG (liquefied natural gas) or electric/battery

[31]https://www.napa.fi/software-and-services/ship-design/structural-design, Retrieved 17 August 2020. design
[32]https://www.cruisemapper.com/wiki/757-cruise-ship-building-construction-design, Retrieved 6 Feb 2020.
[33]https://www.cruisemapper.com/ships/Allure-Of-The-Seas-662 and
https://www.google.com/search?q=harmony-of-the-seas&tbm, Retrieved 19 Jun 2021.

power. Each fuel option needs to be based on vessel type and age, routes or itineraries and power plant. Most new build passenger ships are LNG-powered. World's largest seaports plus numerous smaller ports already have installed shore side power capabilities providing shore-to-ship power supply to berthed vessels. In many ports, shore power is in addition to LNG bunkering capabilities. Without any source of power, the gigantic cruise ships would be nothing more than drifting pointlessly hotels. However large number of older ships uses diesel reciprocating engines for generating power for propulsion. A diesel-electric cruise ship engine system and a huge size of propeller have been shown in fig 16 below.

Fig 16: A diesel-electric cruise ship engine system and a huge size of propeller.

Cruise ship engine power is supplied through the transmission to the propeller shafts. These transmissions determine the revolutions of propellers. Modern ships use either diesel-electric engines or gas turbines as a source of power for propulsion and power generation. Today's larger ships depend on two power sources; one for electrical power and one for propulsion. Gas turbine engines generate heat which is transformed from mechanical energy into electricity. To achieve this, compressed air is fired in a combustion chamber. Hot exhaust is made over a turbine which drive shaft mechanically. The power can be used to spin the generators. The same way work diesel-electric engines and they use a direct drive system. The output shafts, to produce electrical power are connected to generators. The important decision to design a cruise ship is to locate engine room. For stability, ship's heaviest weights are at its lowest possible deck and that's why engines are mounted above the keel. Ship's lowest decks are almost entirely full of machinery. The engine room is an area that creating enough power for driving a massive cruise ship through water is really big. That's why modern mega cruise ship engine rooms occupy at least three decks. Rather than long halls stretching the length of hulls, machinery is almost always divided into smaller compartments; one for the main engines and another for the heating or air-conditioning system.

This compartmentalization is for safety reasons. If a penetration to the hull or fire happens, multiple compartments help contain the damage. Today's direct-drive diesels has one main advantage; the option to use shaft generator, which is a device using the circular motion of propeller shaft in order to generate the electricity needed for hotel services, like cooking and lighting. Almost all new ships feature a diesel-electric propulsion form. On these ships, main engines are not connected to propeller shafts and instead of it they are directly connected to big generators in order to produce electricity. Then this is sent in turn to electric motors, that then power and helps turn the propellers. Main advantage of the diesel-electric cruise ship engine

systems is efficiency; as they allow main engines to operate near the most efficient speed, no matter if the ship is moving either 5 or 25 knots. All ships are supplied with emergency generators to maintain vital electrical power. Backup generators are located higher up and also outside engine room spaces to isolate them from damage or fire.

The new cruise ship propulsion systems ABB Azipods, which has been shown in fig 17 below, are more fuel efficient than traditional systems. It also provides better maneuverability, maximizing speed, reducing bad emissions and which as a whole optimizes ship's performance and enhances passenger safety. ABB Azipod propulsion systems have a major impact on cruise ships operating efficiency, reducing energy consumption and bad emissions by up to 20%. Azipod cruise ship propulsion system is situated outside hull in aft of the ship. Azipod turns in 360 degrees at all directions by a rudder; providing thrust in any directions. And that is not possible for any conventional propulsion systems. Azipod is actually an electric propulsion system. An image of Azipods (2 units) of Oasis-class ship propulsion and that mounted on the hull has been shown in fig 17 below.

The 3rd Oasis-class ship; Harmony of the Seas, is currently the most technologically advanced and energy-efficient cruise vessel ever built. It is equipped with a new-generation exhaust gas cleaning system known as multi-stream scrubbers. It also features a hull lubrication system allowing the ship to float on air bubbles and that created around the hull, thus reducing drag and increasing fuel efficiency. 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.

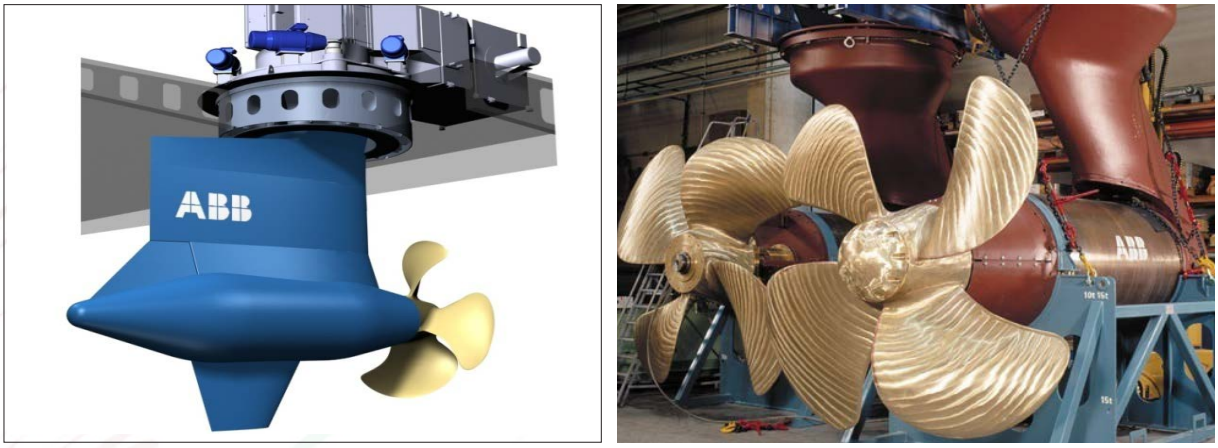


Fig 17: ABB Azipod propulsion systems and Azipods (2 units) fitted on Oasis-class cruise ship.

Cruise Ship Safety

The construction techniques concerning cruise ship safety in 21st century 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. However, to ensuring the safety of cruise ship design is always a great challenge for naval architect and ship builders. But today's cruise ships are safer than any time of past history.

Cruise Ship Present and Future Construction Technology

Modern cruise ship follows compartmentalized design and construction process including modern fire containment and safety systems. Modern cruise ship bridge must be designed to facilitate best all-around visibility. Today's shipbuilding uses many innovations in construction, such as prefabrication, welding, and computer-aided design. The shift to prefabrication together with the innovations of welding and that providing higher quality compared to riveting, have 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. Today, the biggest part done at shipyards is just assembly, but 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. Actually section, block and modular ship construction change the total ship design and construction technology.

Fig 18: Oliver designed Eco-ship and Peace Boat.

Usually luxury cruise ships and liners consume tons of fuel and produce even more sewage that is often dumped directly into the ocean. But cruises don't have to be devastating 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[34], the Eco-ship will produce 30% less CO2 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 continuing 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

[34]https://oliverdesign.es/en/portfolio/ecoship, Retrieved 19 Nov 2020.

Japanese non-profit organization that promotes human rights and environmental sustainability by organizing peace voyages on chartered passenger ships[35]. Two images of Eco-ship Oliver designed and Peace Boat has been shown in fig 18 above[34] [35]. Two link of Eco-ship Oliver designed and Aquarius Eco Ship with zero emission ship design utilizing wind & solar power has been given in the reference[36]. The future cruise will be more comfortable, safer and environment friendly.

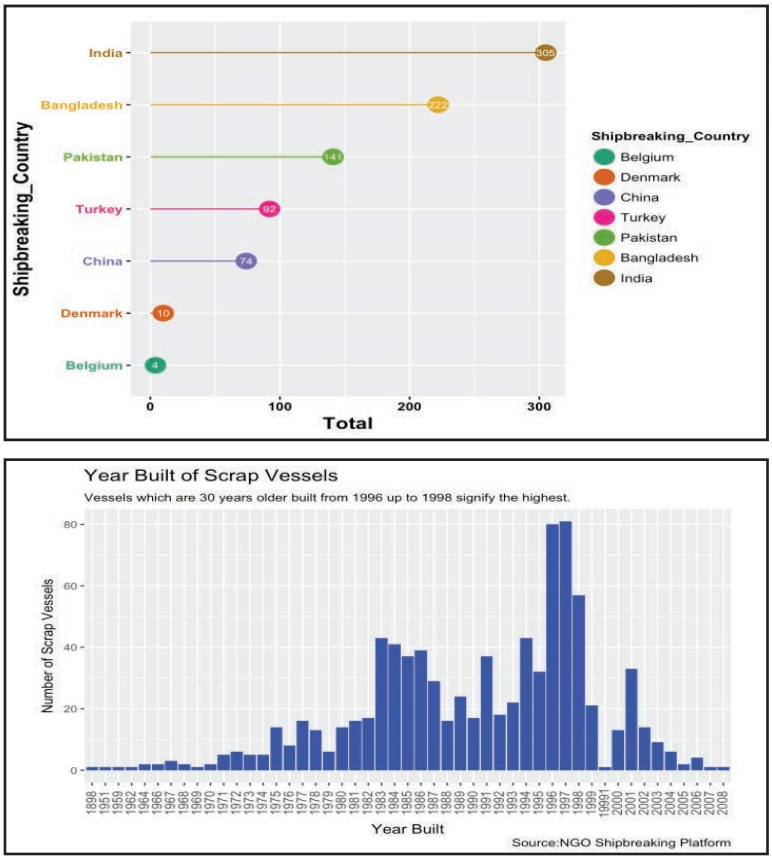
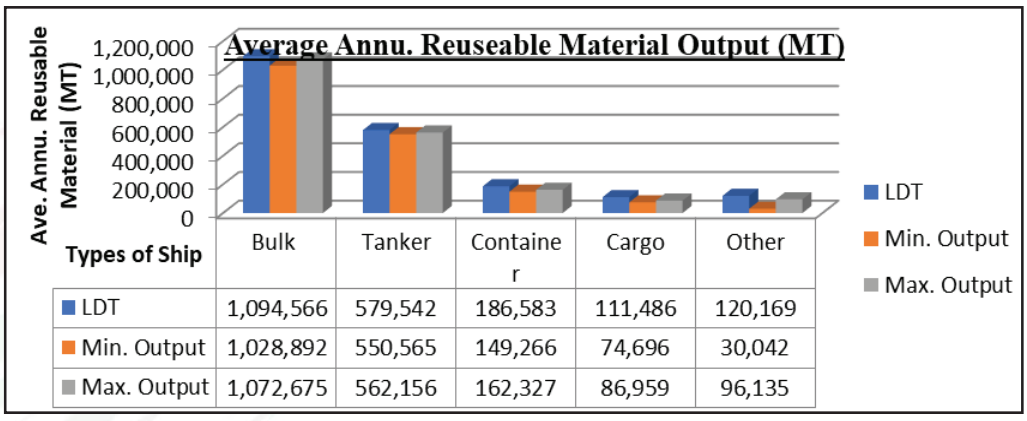


Figure 19 and 20: Major ship recycling countries of the world in 2016 and year of built of scrap vessel recycle in 2016 respectively.



Types of Ship	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).

[35]https://www.ship-technology.com/projects/peace-boats-ecoship, Retrieved 29 Nov 2020.
[36]https://www.youtube.com/watch?v=ptaalRAsVEI and https://www.youtube.com/watch?v=WmikrIcPE6E, Retrieved 11 May 2021.

Global Ship Recycling State

Ships including cruise ship are generally removed from the fleet after end of life (EOL) through a process known as ship recycling or scrapping. There are 933 ships of a combined 44.4 million DWT were scrapped in 2016[37 38 39]. In term of DWT, Bangladesh represented the largest share of demolition activity as they scrapped 199 vessels of a combined 13.6 million DWT in the year 2016[40 41 42]. 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 year of built of scrap ships recycle in 2016[5 38 39] has been shown in fig 19 and 20 respectively above. In Bangladesh, average 200 different types of obsolete ships including LNG and LPG are recycled annually in different yards located in Chottogram[38 41 39 42]. In figure 21 above, total LDT of different types and size of ships including gas carrier recycled and reusable material output in Bangladeshi recycling yards between the years 2009 to 2015 has been shown. Bangladeshi recycling yards are dismantling around 30% of global EOL ships in term of DW.

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[37]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.

[38]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.

[39]Hossain K. A. and Zakaria, N. M. G., Proposed viable ship recycling process for South East Asian recycling yards especially for Bangladesh, Procidia Engineering, 2018.

[40]Hossain K. A., Material Flow Analysis Technique for Material Assessment of Ship Recycling Industry, Bangladesh Maritime Journal, BSMRMU, Vol 3, Issue 1, Jan 2019.

[41]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

[42]Hossain K. A. and Zakaria, N. M. G., Estimation of reusable and waste materials of ship recycling industry of Bangladesh, Procidia Engineering, 2018

Author's Brief Biography

Commodore Khandakar Akhter Hossain is a renowned engineer and naval architect and working since 31 years with excellent reputation in home and abroad. He has thirty years' experience in shipbuilding, repair, re-cycling, port planning development and management, pollution control, waste management, clean environment, blue economy and energy field. Commodore Akhter has joined Bangladesh Navy as cadet and commissioned in 1990. He did his BSc and MSc Engineering in Naval Architecture and Marine Engineering with distinct result from Bangladesh University of Engineering and Technology (BUET). He did his PhD from American World University, California, USA in Engineering Management. He also did his 2nd PhD from BUET in Naval Architecture and Marine Engineering. He has around fifty research papers/articles published in various National and International Journal. He did MESC and ISMC from Pakistan and the USA respectively. He completed his MBA from Dhaka University. He served as chief engineer onboard different warships including five Frigates & Corvette and modern missile Frigate BNS BANGABANDHU and as instructor in Naval Academy, Marine Academy, NIT and MIST. He worked as GM (Shipbuilding), GM (Planning, design & QC), and GM (Production), in Khulna Shipyard, Chattogram Dry-dock and Narayangonj Dockyard respectively. He also served in UN Peace Keeping Mission as Staff Officer in Sudan and directorate in Naval Headquarters and in Chittagong Port as member engineer. He is a fellow of prestigious institutes like IEB (BD), RINA (UK) and IAMSP (USA). He performed the duty of Managing Director of a historical shipyard Narayangonj Dockyard Ltd before his present appointment. Presently he is working as Managing Director, Khulna Shipyard Ltd.

Strength Weakness Opportunity Threat (SWOT) Analysis of Bangladesh Shipbuilding Industry

Commodore Khandakar Akhter Hossain, NUP, psc, PhD, BN
Md. Mezbah Uddin

Introdcution

SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is a well-known technique that usually utilized to assess and guide to an industry to find out its competitive position and to develop future goal and strategic planning. SWOT analysis is an effective tool for assessing the performance, competition, risk, and potential of a business, as well as part of a business such as a product line or division, an industry, or other entity. SWOT analysis surveys internal and external factors, as well as current and future potential. A SWOT analysis is designed to encourage a realistic, fact-based and data-driven to see the qualities and weaknesses of an organization's initiatives, activities and its overall financial state.

The organization should keep the investigation exact by maintaining a strategic distance from pre-conceived convictions or gray regions and instead centering on real-life settings. Companies should use it as a guide and not necessarily as a prescription. Using internal and external data, the technique can guide businesses toward strategies more likely to be successful, and away from those in which they have been, or are likely to be, less successful. Independent SWOT analysts, investors, or competitors can also guide them on whether a company, product line, or industry might be strong or weak and why. Bangladesh has a famous history of shipbuilding including its effective and lowcost workforce. In this article, SWOT analysis technique has been used in shipbuilding industry of Bangladesh to evaluate present state and develop future guidelines and surveys it's all the internal and external factors, variables and data to find out the industries Strengths, Weaknesses, Opportunities, and Threats.

STRENGTHS: Bangladesh has all necessary facilities to establish herself as an emerging shipbuilding nation in the international arena due to her long and illustrious history in Maritime Industry. The presence of shipyards in particular for long time with large pool of workforce is the main strength of Bangladesh shipbuilding industry. The following are the areas of strength:

a. The major strength of Bangladesh shipbuilding industry is the Labor, which is comparatively cheaper than any other country in the world. The Bangladeshi labors are very hard workers and devoted to the service.
b. Bangladesh has got a very good riverine network connected to the sea and still there are ample places to build or expand existing potential shipyards[1].
c. Supports of backup industries are also cheaper in respect to the shipbuilding industries of other nations.

[1]Hossain K. A., Iqbal K. S. and Zakaria N. M. G.; Evaluation of the performance of contemporary shipbuilding industries in Bangladesh; Journal of Naval Architecture and Marine Engineering; vol 7, No 2, (http//www.banglajol.info/index.php/JNAME/issue/view), 2010

d. There are a good number of re-rolling factories, which uses scraped MS plate as raw material and can produce new accessories for shipbuilding industry.
e. Long and glorious shipbuilding history of Bangladesh encourages entrepreneurs to come forward in this field.
f. Presence of convenient geographical advantages.
g. Availability of easily trainable work force (a little training is necessary to elevate the existing workforce to international standard). Availability of white color skilled manpower in maritime field. Bangladeshi workforce is acclaimed to be disciplined, diligent, hardworking, obedient and quick learner[2].
h. Management professionals, electronic, electrical, information technology and communication engineers of the country are capable of performing the assignment in relation with shipbuilding with little training.
i. Presence of various supporting industries, which may contribute as backward, and forward linkage industries.
j. Availability of cost-effective human resources of whom a good number of skilled manpower are now working overseas.
k. The classification society is extending very good support in guiding for quality and also certifying the material lists. Germanischer Lloyd (GL) and NK have been playing a very vital role in the growth and development of export shipbuilding in Bangladesh[3].
l. Careful comparison of prices of China and Bangladesh have been made and the price of Bangladesh have been found to be better, which is to be contracted and continuously improved, otherwise many cancellations or order in China due to recession can reverse the things.
m. Because the buyers have had the experience of building vessels in countries that are competitors of Bangladesh, especially Korea, China, India etc and they have come to Bangladesh to place orders and have been builder friendly in some cases. Previously China was cheaper but because of their standard of living is becoming higher their wages have also been increased. Bangladesh remains in advantageous position[4].
n. Recently Govt. has taken some step to improve the shipping and shipbuilding sector as a whole like; dredging of rivers, tax free activities for export-oriented shipyards, ease of rules for shipbuilding, declare some development strategy for the industry and negotiating with related other sectors to improve the local shipbuilding.

WEAKNESSES: In spite of enormous possibilities of expanding shipbuilding industry in Bangladesh there also exist some Weaknesses, which have to be taken into consideration. The weaknesses are listed below:

a. Despite long heritage, Bangladesh has failed to keep pace and consistency with the continuous technological development of global shipbuilding industry.

[2] Hossain K. A., Rahman M. M., Akimoto H., Zakaria N. M. G., and Shabnam S., Prospects of virtual or computational towing tank facility for the shipbuilding industry of Bangladesh, Global Institute of Science and Technology Conference 28-29 Dec 2012, Australia www.gistconpro.com. 2012

[3] Hossain K. A., Rahman M. M. and Zakaria N. M. G.; Study on some competitive parameters for shipbuilding industry in Bangladesh; International Conference on Marine Technology: International Conference on Marine Technology; MARTEC 2010 Proceeding; (http://www.buet.ac.bd/name/martec2010/2010/contents.htm), 2010

[4] 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

b. Policy planners, government officials, stakeholder, bankers, etc. generally are not aware of this sector and its' potential. As a result, development of the sector is progressing at a slow pace[5].

c. Other than government owned dry-dock, none of the shipyards have the dry-docking facilities.

d. There is no local backup industry to produce required standard of MS plate need for ship construction.

e. The shipbuilding industry of Bangladesh has mostly to depend on the foreign providers to procure the major item i.e. MS plate and other machineries like engine, generator, pumps, machineries, components etc.[6]

f. Lack of activities to promote Bangladesh as a shipbuilding nation. Information on prospective overseas buyers is limited. Government foreign affair department and ambassadors are not playing adequate role in this matter.

g. The industry lacks with technical expertise and modern technologies for building comparatively medium and large ships, which will obviously hinder the sustainability of the industry.

h. The key weakness of the industry is the dishonesty and fraud character of the people. Some people of the country usually try to cheat and apart from normal profit, they want to gain more by bluffing.

i. Poor management practice observed in most of the local shipyard. Family member are running local shipyards as per their desire and aspiration[7]. They hold all the key and top appointments and consider employee as their servant. As a result, there are distinct gap between shipyard owner and employee.

j. There is no corporate management culture practiced in local Shipyards. Poor job satisfaction observed among the middle management and skilled workforce. Workforce never enjoys fringe benefit and other labor welfare activities like medical, pension, travel & daily allowance, accident & other compensation, etc. Most of the labor is employed casually.

k. Working environment is not up to the standard. Local Shipyards owners do not bother about working environment and welfare of the employees due to availability and cheap labour.

l. Substantial number of graduates and other skilled manpower trained in Maritime Industry leave the country for overseas employment.

m. Shipbuilding industry's standard is changing rapidly with the up-gradation of technological advancement. But unfortunately, technological enhancement is going very slowly and there

[5] Hossain K. A., and Zakaria N. M. G., Service provides and supporting industries of shipbuilding sector on Bangladesh and its impact on overall development of shipbuilding; Proceedings of the 6th International Conference & 13th Annual Paper Meet 30-31 Dec 2009, Dhaka, Mechanical Engineering Division; The Institute of Engineers, Bangladesh (IEB), 2009.

[6] Hossain K. A., Zakaria N. M. G. and Ali M. T., Underlying problem of ship recycling industries of Bangladesh: Journal of Naval Architecture and Marine Engineering; Vol 9, No 2, (http//www.banglajol.info/index.php/JNAME/issue/view), Sep, 2012

[7] Hossain K. A., Shipbuilding Industry is a Strategic Industry of Bangladesh in Line of Vision 2020; Journal of BAYR, 2011 Hossain K. A., and Zakaria N. M. G., Export Oriented Shipbuilding Industry in Bangladesh; Present Status & Way Forward; 6th International Mechanical Engineering Conference & 14th Annual Paper Meet 2012; 28-29 Sep 2012.

are no initiatives to strengthen our Research and Development (R & D) directly related to this industry sector which is extremely important for the survival of this competitive business[8].

n. Because the industry is not understood properly by concerned policymaker, as a result the usual responses to such investment proposal are lukewarm and are treated in the same format as in case of other export sectors. Thus, banking support that the shipbuilding sector enjoys in the current policy is poor.

o. Shipbuilding requires guarantees to be issued by banks acceptable to foreign buyers. But Bangladeshi commercial banks have to obtain counter guarantees from foreign banks. This adds to the cost of finance.

p. From the discussion with Shipbuilders and Banks it is visualized that Bank interest and service charges are too high in this Sector compared to other competitors. This is the major obstacle to develop shipbuilding industry in Bangladesh.

q. Image problem of the country hinder the growth of export oriented local shipbuilding. Lack of collective marketing activities for the industry further expedite the hinder.

r. Poor training facilities of the technical personnel observed in almost local shipyards. Most of the local shipyards' owner considers that, every human resource development programmed as money drain not gains.

OPPORTUNITIES: Countries with large population like Bangladesh got golden opportunity to come forward in labour intensive shipbuilding sector due to their abundant manpower. The following are the areas of opportunity:

a. Country has got all the potentials to penetrate the world shipbuilding industry. This industry can earn huge foreign exchanges by building qualitative ships.

b. There are chances to have more employment facilities. Because, there are availability of easily trainable work force. A little training is necessary to elevate the workforce to international standard. Moreover, white color skilled manpower in marine field is available[2].

c. There is an opportunity to produce skilled manpower due to growing shipbuilding as a labour-intensive industry.

d. There is a golden opportunity to surfaced backup industries in support of shipbuilding.

e. There is a prospect to be a dominant foreign currency-earning sector within next few years.

f. Duty free market access of Bangladeshi ships in developed countries.

g. The foreign buyers have exhausted Korea and China and exploited them up to the extreme by imposing the mandatory requirement of using their own equipment in the ordered ships (specially, Stella shipbuilding has been exploiting in this way).

h. The govt. shipbuilders, ship owners and the concerned agencies are already understanding that, one ship owner/builder can make earning equivalent to 10 garments manufacturing in most of the cases.

i. Existing local shipyards of Bangladesh can manufacture quality ships with competitive price.

j. Present financial crisis may increase demand for lowest cost ships. This is favorable for Bangladesh shipbuilding.

[8]Hossain K. A., and Zakaria N. M. G., Export Oriented Shipbuilding Industry in Bangladesh; Present Status & Way Forward; 6th International Mechanical Engineering Conference & 14th Annual Paper Meet 2012; 28-29 Sep 2012.

THREATS: Shipbuilding industry of Bangladesh failed to keep pace and consistency due to lack of proper government and private initiatives. This has ultimately caused non-penetration in international business as a shipbuilding nation. The threats are listed below:

a. Like Bangladesh, many other countries like Indonesia, India, Brazil, Pakistan, etc are also trying to capture the surplus market of this global shipbuilding industry[4].
b. Draining out skilled manpower from Bangladesh shipbuilding industry to foreign industry.
c. The raw materials for local shipbuilding industry are of import-based. So overall costing will be dependent on the importing cost of those items.
d. As the nature of some Bangladeshi is to cheat and fraud other and to become rich at the shortest span of time, this can be a huge threat for the overall existence of all Bangladeshi shipyards. As the mission of local shipbuilding industry is to penetrate the world market, so there are risks to maintain the reliability of quality to the foreign buyers[9].
e. Timely delivery is an important issue for shipbuilding industry. Most of the shipbuilding nations have developed close links between shipbuilding and equipment industry for reducing delivery time. But owing to non-availability of industries of marine equipment approved by classification society in Bangladesh, the length of delivery time is longer in comparison to the competitors and resulting in cost inflation as well as negative notion about Bangladesh.
f. Scarcity of sufficient land in Bangladesh, deficiency in power supply and weak infrastructure facilities are the major impediments for rapid development of shipbuilding industry[10].
g. Existing inadequate infrastructure facilities of the country discourages development of shipbuilding industry. An absent of expert's favor earmarking a special zone for healthy growth of shipbuilding industry in Bangladesh create hindered for the industry.
h. Due to poor management culture in the local shipyards, poor job satisfaction observed and employee does not feel belong to the organization. As a result, huge absenteeism and turnover of labour and skilled manpower observed in local shipyards.
i. Lack of mechanism for proper implementation, monitoring and updating strategy for ship export.
j. The rivers and channels are frequently silted. It is very difficult to maintain channel for desired level of navigability for ships maneuver.
k. Shipbuilding industry needs a lot of components, parts, and accessories leading to emergency import during the construction period. Existing facilities are not adequate for emergency import requirements. Under the present import policy and foreign currency regulation; CIF basis import is not permissible. Ultimate result is delay in delivery of ship to foreign buyers.

[9]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

[10]Hossain K. A., Global Energy Pattern and GDP; International Journal of Renewable Energy Technology Research (IJRETR); Vol. 1, No. 1, PP: December 2012; ISSN: 2325-3924 (Online); www.ijretr.org. 2012.

Author's Brief Biography

Md. Mezbah Uddin has graduated in Naval Architecture and Marine Engineering from BUET in 2011 and completed his MSc. in Naval Architecture and Ocean Engineering from Chalmers University of Technology, Gothenburg, Sweden in 2013. Currently he is pursuing his PhD in Mechanical Engineering at BUET. He is working in the department of Naval Architecture and Marine Engineering in Military institute of Science and Technology (MIST) as Assistant Professor from July 2015. Before that he has worked as Lecturer in the same department of Military institute of Science & Technology (MIST) from January, 2014 to June, 2015 and as Intern in the Hydrodynamics Department at GVA Consultant AB, Gothenburg, Sweden from January, 2013 to November, 2013. His teaching and research interest includes Composite Materials, Fatigue and Crack Analysis, Finite Element Method (FEM) Analysis, Fluid Structure Interaction (FSI) Analysis, Structural Analysis

Horizon of Research in Naval Architecture and Marine Engineering

Commodore M Muzibur Rahman, (E), psc, PhD, BN (Retd)

Engineering is a profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to the efficient utilization of materials and methods for the benefit of mankind. At the same time, engineering is profoundly a creative activity to make the life easy and develop the society. Many of the problems facing the society today are new and complex because of climate change, over population, information overflow, healthcare concern, environment concern, etc. Engineers must constantly innovate new solutions and invent new ways of solving problems. Therefore, engineering in any discipline is to be of creative in nature to enhance the existing technology or to invent new technologies.

Naval Architecture and Marine Engineering (NAME) is a multi-disciplined field of study where mechanical engineering acts as pivot which takes civil, electrical, electronic and computer engineering alongside for design, operation and maintenance of sea borne structure and machinery, on-board systems, oceanographic items and exploration/exploitation of living and non-living resources from sea. Due to versatility of the field, its research opportunities have a wide range of horizon and it proceeds in the competitive pace with all engineering disciplines. Rather, it demands more caution many a times in the use of materials and methods for marine technology due to the need of specialization in design, construction, conversion, repair, surveying and decommissioning of marine vehicles in the frontline of civilization. This specialization comes from the requirements of sufficient structural strength of a dynamic body to sustain on the waves in hostile weather at sea, operational reliability of machinery, protection of hull and systems from corrosion in aggressive sea water environments, etc. As of today buoyant world trade, a thriving leisure industry, the need for national defense, etc. clearly signpost that the marine vehicles will continue to remain as a dominating factor, which continues to push the researchers to proceed ahead with new design, advanced materials, innovated components and efficient systems so that the modern ships must possess good S3 i.e., strength, stability and speed along with good C3 i.e., comfort, communication and control in line with national and international norms, rules and regulations. Moreover, a ship contains huge items similar to a cosmopolitan city, which need everything starting from electric power houses to sewerage systems. The complexity of many engineering things in a compact space in a ship necessitates the naval engineers to devote on each and every equipment and system to make it absolutely worthy in all parameters including weight, dimension, performance and durability in marine environments.

Basically, researches in the field of naval engineering started in pre-historic era, which takes us back to the time of Prophet Noah (A) as the pioneer naval architect, whose designed and constructed safina (vessel) was absolutely sea worthy at the greatest flood occurred ever in the history of mankind. Then the world could observe scientific development and civilization through naval

researches and corresponding expeditions worldwide. Every school going student knows Christopher Columbus (an Italian) who tried to find the western route to Asia, however stumbled upon the America (in the Bahamas, Cuba and Hispaniola) in 1492 AD and John Cabot (another Italian) who tried to reach Asia in 1497 AD, but reached the coasts of Newfoundland and Labrador of Canada instead. Many of also know Vasco da Gama (Portuguese) whose voyage to India (1497–1499 AD) was the first to link Europe and Asia by an ocean route connecting the Atlantic and the Indian oceans. This is widely considered a milestone in world history as it marked the beginning of a sea-based phase of multiculturalism. Then one can find another Portuguese sailor, i.e., Ferdinand Magellan embarked in an expedition in 1519 AD to look for the western maritime route to Asia. He successfully reached the Pacific Ocean by rounding the southern tip of South America in 1520 AD and by going through the strait that would later bear his name, i.e., Magellan strait. Though after crossing the Pacific Ocean, he died in 1521 in Southeast Asia, but one of his ships made the trip back to Europe through the Cape of Good Hope and completed the first round-the-world journey in history (1522 AD). All these expeditions derived huge number of discoveries and modernization of vessels in design, construction and operations over the sea through extensive researches.

Even if we talk about modern era, there are numerous historical evidences of naval contribution in the development of science and technology. Few of them can be mentioned here. Development of paddle wheel propulsion and then screw propeller were the paradigm shift in the domains of naval research. Then we can remember the name of Mr. William Froude whose invention on hydrodynamic field such as Froude number, floating body resistance, etc. are well known. However, many of us do not know that he was a great naval engineer of 19th century. A naval engineer of today can find number of lessons from his researches and contributions to enhance further. We can also look at the researches of David Watson Taylor, another renowned naval engineer, who contributed to develop the most modern fleets of US Navy.

Micro-oven is very common item in everybody's house. But many of us do not know that the main component of this micro-oven, i.e., magnetron was invented by a naval engineer to be used for the radar onboard ships. Then comes the discovery of renowned smart material, i.e., shape memory alloy (SMA) by Beuhler in the Naval Ordnance Laboratory of USA. The newly invented material got the name as Nitinol which is the short form of Nickel Titanium Naval Ordnance Laboratory. Principally numerous events can be cited on the contribution of naval ordnance laboratory on research in engineering field.

Once the classical antifouling paints for ships containing tributyltin (TBT) was banned by the International Maritime Organization (IMO) in 1970s due to its serious toxic effects on marine life such as the collapse of a shellfish fishery. A big hue and cry occurred including the investigation at Port of San Diego to reduce copper input from antifouling coatings. USA also passed a law to phase-wise ban on copper based antifouling coatings to reduce the discharge of toxicity in sea water. To cope up with the situation, naval engineers immediately took up researches on the use of smart paint for antifouling purpose mitigating the environmental issues and has made remarkable progress within a short period. Actually, the creativity of naval engineering research emerges within the constraints of physical laws, commercial considerations, the needs of the client or employer, society and ethics. Moreover, constraints provide boundaries within which to explore problems

and propose engineering solutions. In this scenario, smart paint has not only got momentum for antifouling requirement but also for stealth technology. Now the researches in naval engineering laboratories are at very high altitudes on the consideration of absconding the radar cross-section using smart paint for war ships. Naval engineers are now working with the concept of complete disappearance of a ship from radar detection. As a whole, there is a hide and seek competition between the radar technology and stealth technology

Need for higher speed, fuel-saving, low emission and automation are great factors that have driven naval engineering researchers to work with the improvement of hydrodynamic shape of vessels, modification in fuel combustion process as well as its chamber design, development of energy saving mechanism through nanotechnology, application of alternate fuels, incorporation of fuel cells and solar panels, etc. Naval researchers can very well contribute in the technologies of air independent propulsion (AIP), which include Closed Cycle Diesel (CCD) Engines, Closed Cycle Steam Turbines (CCST), Sterling Cycle Engines, Fuel Cells, etc. Therefore, research scopes for a naval engineer is so vast that he/she can pick up any relevant field to earn higher degree or even may reach to a respectable social position or award.

To carry out such researches, one needs to understand what actually research is and how to do it. Research is an object-oriented systematic search for obtaining and confirming new and reliable information/knowledge on a particular topic or issue. It is an investigation of finding solutions through scientific analysis that can lead to a discovery of hidden truths or new things. All well designed and well conducted researches have to have novelty, simplicity and universality, which drive the outcome to a potential application. Therefore, researches of today needs to apply modern tools to achieve the potential objectives and thus naval engineers are now required to pay especial attention on wide ranging numerical tools like computation fluid dynamics (CFD), finite element methods (FEM), finite volume methods (FVM), etc. As a result, computer programing skill is essential to conduct a research and bring out some fruitful results. At the same time the numerical computations will be needed to be validated using experimental works. So, the academic institutes are to be prepared to provide both computational and experimental working facilities in the laboratories to attract the researchers and bring out worthy findings. In this regard, following facilities might have good merits:

i. International standard towing tank for the assessment of speed and stability along with hydrodynamic configurations of ships,
ii. Materials' characterization laboratory equipped with corrosion testing, wear testing, tensile testing, fatigue testing, thermal capacity testing, etc. to ascertain the marine grade quality for hull and machinery,
iii. Micro-processor based marine controls and monitoring system laboratory to have innovations in steering, stabilizer, emission mitigation, etc.
iv. Marine machinery testing laboratory for performance assessment of marine diesel engine, gas turbine, etc. along with component level calibration facilities.
v. Under water vehicle laboratory including imaging and robotics.

In the conclusion, it may be mentioned that the research scopes for a naval engineer are not limited to the field mentioned for own purposes. It is also available with allied engineering such as nuclear engineering for nuclear propulsion of air craft carrier and submarines, petroleum engineering to be

involved in rig fabrication and siting for the oil and gas industries, communication engineering in lay out of fiber optics submarine cable, etc. Even naval engineers may carry out researches in building underwater parks in conjunction to URP professionals to open a new horizon of tourism. All these can bring new technological innovations, advanced design and production methods, and ensuring the utmost application of the technology in efficient manner.

Author's Brief Biography

Commodore M Muzibur Rahman, (E), psc, PhD, BN (Retd.) has graduated in Naval Architecture and Marine Engineering from BUET in 1991 and has completed his Master of Science in Mechanical Engineering from BUET in 2009. He has completed his PhD in Mechanical Engineering from BUET in 2021. He had his Master in Defence Studies in 2003 from National University, Bangladesh and Master in Business Administration in 2013 from Northern University, Khulna, Bangladesh. Cdre Muzib (Retd.) has instructed many professional courses in India, Germany and United Kingdom. His teaching interest includes Marine Engineering and Industrial Management. During his 25 years of carrier, he was in a number of positions in Bangladesh Navy; namely General Manager, Dockyard & Engineering Works Ltd, Narayanganj; Deputy General Manager, Khulna Shipyard Ltd, Khulna; Deputy Director, Dte of Naval Engineering, NHQ, Dhaka and as Engineer Officer in different Naval Ships. He was awarded "Shri Baddri Prasad Shrivastava" trophy for standing first in Marine Propulsion Control Technology Course (MPCTC) in India. He served as Dean, Faculty of the Science and Engineering and Head, Naval Architecture and Marine Engineering department of MIST. Currently he is working as a full time Professor in the department of Naval Architecture and Marine Engineering at MIST.

Laboratories in Naval Architecture and Marine Engineering - Understanding the Real World

Captain M Enayet Kabir, (E), psc, BN

I hear and I forget;
I see and I remember;
I do and I understand.
-Chinese proverb

Introduction

The overall goal of engineering education is to prepare students to meet the requirement of the society and deal with the problems faced by itself. Engineering education gets completed only when it is learned through laboratory practices. That is why the laboratory practice has been an important part of professional and engineering undergraduate education.

MIST is equipped with the best laboratories for the students and researchers. In MIST laboratories, students learn in a real-world environment, function as team members, discuss the planning of experiments, and share ideas about the analysis and interpretation of data.
These labs are regularly upgraded with the latest technological advancements in the respective fields of engineering. This allows students to be acquainted with the current technologies instead of the outdated ones.

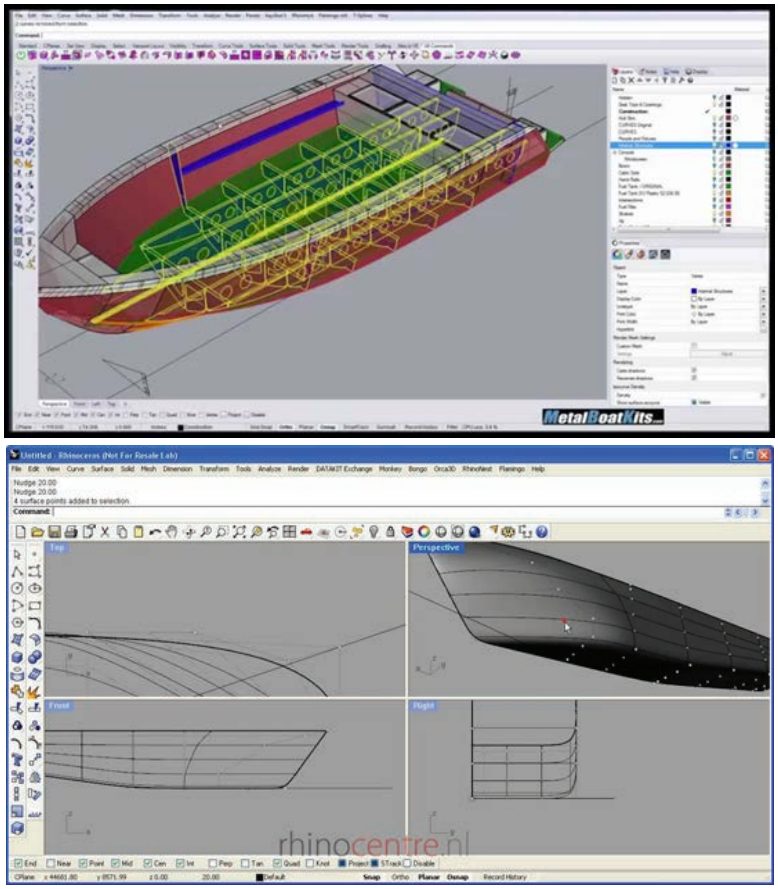
In MIST, the laboratory courses help students to gain insight and understanding of the real world which they learn in their theory courses. The emphasis on laboratories has increased many folds over the years. Now attention has been paid to laboratory courses in the curriculum and teaching methods. Students can understand their text book learning by observation and doing. Students in NAME department have to design, analyze, and build their own creation.

Naval Architecture and Marine Engineering Facilities

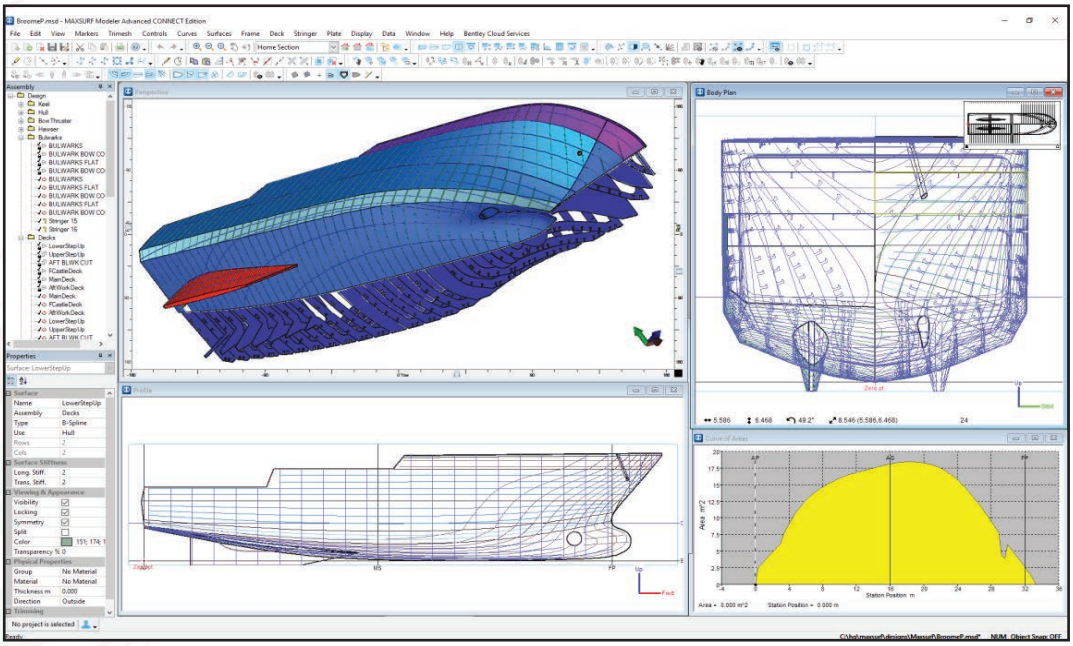
The Department of Naval Architecture and Marine Engineering is home to more than 40 instrument facilities and laboratories, led by our faculty in the field of engineering and applied sciences. The instrument facilities and laboratories are available to our faculty, research staff, graduate and undergraduate students. The department endeavors to provide its faculty members and students with adequate laboratory and other facilities, departmental undergraduate courses are laboratory intensive and post-grad students can also avail these laboratory facilities for their research and projects.

These requirements are catered for by following laboratories:

Computer Aided Ship Design Lab



Student's Project Based on RHINOCEROS 5



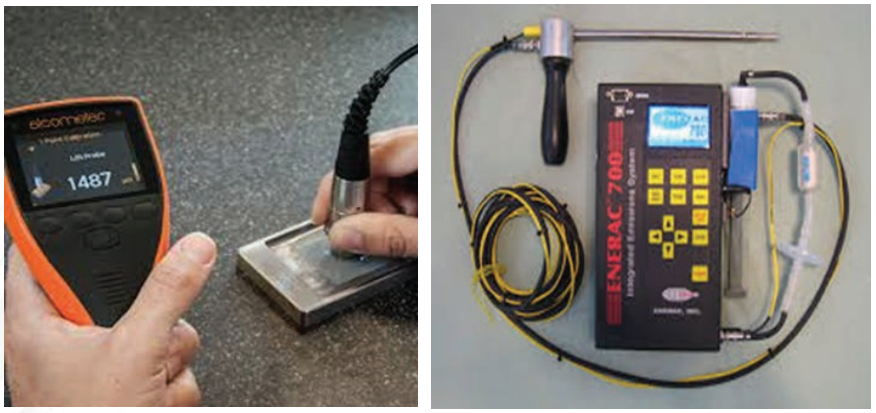
Student's Project Based on MAXSURF

Students attending Class on RHINOCEROS 5 & MAXSURF

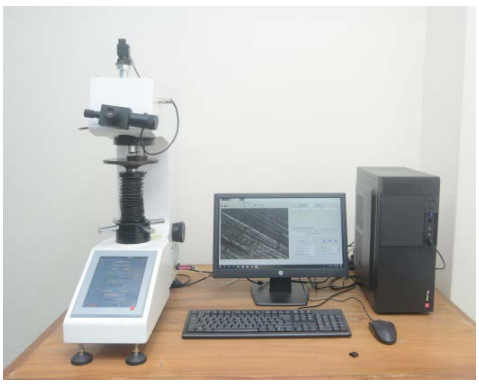
In supporting the activities of ship design lectures and ship design assignments, the Department of naval architecture has a Ship Planning Laboratory assisted with computers, in this lab equipped with computers that can be used by students to conduct research or final assignments in ship hull modeling or 3D ships. The lab is fully networked and provides access to other online resources. Some of the software we use are Maxsurf, Rhinoceros, AutoCad etc.

Ship Structure and Fabrication Lab

The activities within the Ships Structure and Fabrication Lab focus on the construction and fabrication of the ship in an offshore environment. The lab further facilitates and demonstrates the principal materials used in the construction of the main components of a ship or marine structure, including steels, aluminum alloys and composites, the effects of corrosion, corrosion control, and antifouling. It outlines typical examples of ship structure, shipyard layout and shipbuilding process is given, together with a description of the links between the designs, drawing and manufacturing process Marine Machinery Lab



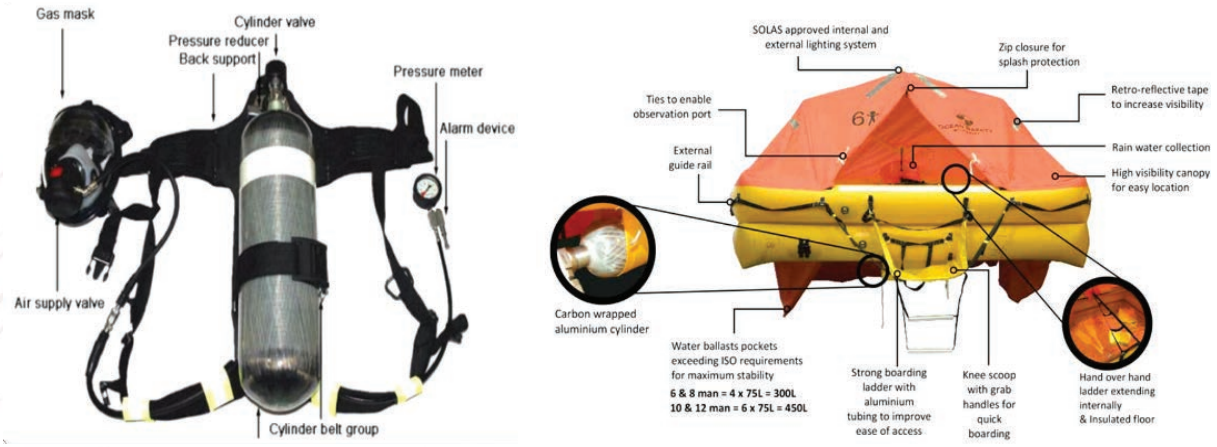
Lab Equipment-Paint Coating thickness Test & overview of Emission Analyzer



Lab Equipment-Micro Vickers Hardness Tester, Corrosion Thickness tester & Current Conductivity Meter.

The activities within the Ship Instrument Lab focus on the inspection and quality assurance of the ship. Students can carry out different inspections to determine an items or system's fitness for use or conformity in the ship. Different types of tools and instruments are present in this lab including Handheld x-ray fluorescence for material compositions analysis, Integrated Emissions System, Electromagnetic yoke for surface cracks detector, Paint coating thickness gauge, Corrosion thickness gauge, Eddy current conductivity meter, Vickers micro-hardness tester etc.

Damage Control, Fire Fighting and Life Saving Lab



Lab Equipment-Self Contained Breathing Apparatus (SCBA) & Life Raft

The safety of passengers and crew on ships is of paramount importance while ships are conducting their commercial activities. Therefore, ships must carry appropriate life-saving appliances, including lifeboats, lifebuoys, life-jackets, life-rafts and many others to be used by passengers and crew in case of emergency to protect their lives at sea. Apart from the stringent rules and regulations followed during ship design and construction, it is mandatory to carry onboard certain fire-fighting and life-saving equipment and appliances, which are helpful in saving the lives of people in the event of a disaster. This lab focuses on the use and maintenance of fire-fighting and life-saving equipment present onboard ships.

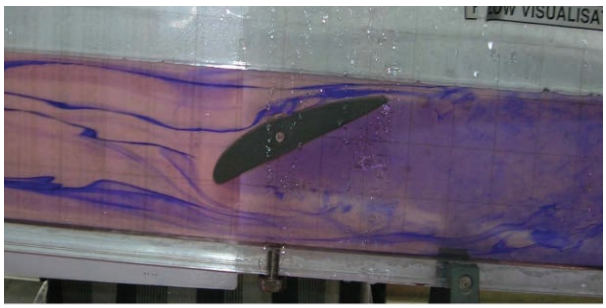
Ship Propulsion Lab


Lab Equipment- Engine with Ship Propulsion System

Marine propulsion systems move ships through the water, ensures a better safety standard for the marine ecosystem and are cost-efficient. The propulsion system on a vessel can be as simple as a diesel engine directly connected to a propeller shaft, which drives the propeller, or more complex systems containing diesel engines powering an electrical generator, supplying electrical power to an electrical motor through a sophisticated control system. The students study marine engine propulsion system through the live engine.

Marine Hydrodynamics Lab


Lab Equipment- Hydraulic Bench, Pitot Tube Apparatus & Laminar Flow Demonstration

Lab Set up- Open Channel Flow at Hydraulic Bench

The Marine Hydrodynamics Laboratory facilities the classic naval architecture experiments. This lab supports education and research at the Department of Naval Architecture and Marine Engineering. The staff provides technical guidance and support in experiment design, instrumentation use, and design,

and conducting the experimental tests. We also conduct fundamental research in areas of current interest such as hull form drag reduction and planning hull and surface effect on ship dynamics, renewable ocean energy harvests, advanced material in marine propulsions and control surfaces.

Marine Machinery Lab

Diesel Engine Cut View, Diesel Engine Spare Parts & Universal Drill Machine

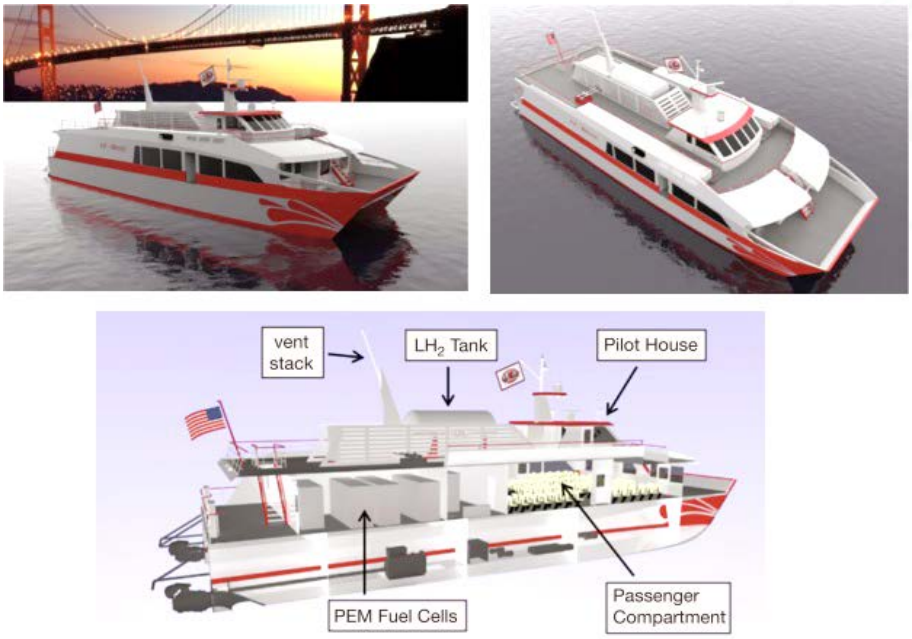
This laboratory is currently the best equipped independent engine laboratories in MIST. Well-developed basic installations, highly specialized experimental equipment, instrumentation and data-acquisition systems, and a team of experienced staffs is a crucial asset in providing professional support to our students. Students acquire insight of functions of different engine parts, study of the engine working principles and operation, starting system, fuel line system, cooling system, lubricating system and air intake exhaust system. Students can also identify and study functions of different engine parts, disassembling and reassembling the engine and complete the testing the assembly procedure by starting the engine.

Towing Tank & Stability Test Lab

Image of Ship Towing Tank & Stability Trial Test

This laboratory is currently the best equipped independent engine laboratories in MIST. Well-developed basic installations, highly specialized experimental equipment, instrumentation and data-acquisition systems, and a team of experienced staffs is a crucial asset in providing professional support to our students. Students acquire insight of functions of different engine parts, study of the engine working principles and operation, starting system, fuel line system, cooling system, lubricating system and air intake exhaust system. Students can also identify and study functions of different engine parts, disassembling and reassembling the engine and complete the testing the assembly procedure by starting the engine.

Marine Transportation Lab



Different Section & Image of Marine Passenger Ship

Marine transportation includes cargo-carrying commercial shipping (e.g., merchant marine) and non-cargo commercial shipping (e.g., ferries, cruise ships). We ship food, technology, medicines, and memories. As the world's population continues to grow, particularly in developing countries, low-cost and efficient maritime transport has an essential role to play in growth and sustainable development. Maritime transport is the backbone of global trade and the global economy.

Ship Model Fabrication Lab

The modern method is to construct large parts of the hull, for example, the complete bow and stern. Modelling precision and lightweight design can be achieved by creating a hollow hull. The plank on bulkhead technique inserts a series of shaped bulkheads along the keel to form a shaped stage which will be covered with planks to form the hull of the model.

Ship Resistance Lab

Ship resistance is defined as the force required to tow the ship in calm water at a constant velocity. The motion of a ship through water requires energy to overcome resistance, the force working against movement. As the resistance of a full-scale ship cannot be measured directly the knowledge about the resistance of ships comes from model tests. The total resistance on calm water can be divided into three main components: frictional resistance, residual resistance and air resistance. The frictional resistance depends on the size of the wetted area. It represents often about 70-90% of the ship total resistance for low-speed ships (bulk carriers and tankers), and sometimes less than 40% for high-speed ships (containers and passenger ships).During the operation of ship, the paint film on the hull breaks down. Erosion starts, and marine plants and barnacles, etc. grow on the surface of the hull. In addition, the propeller surface can become rough and foulded. The total resistance caused by fouling may increase by 25-50% throughout the lifetime of a ship. Resistance also increases because of sea, wind and current. The resistance when navigating in head-sea could perhaps increase by as much as 50-100% of the total ship resistance in calm weather.

Hull Vibration and Noise Control Lab

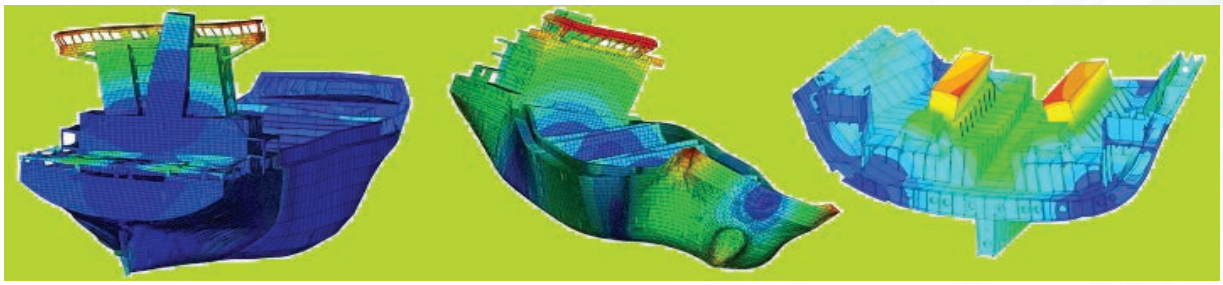


Figure of Ship with Vibration Noise

Ship noise and vibration control is a complex phenomenon happen on ship and machinery space, to understand and have the first sight of vibration assessment or further development, the fundamental of vibration theory is the great article for your pre-learning with such concept. As defined, any motion that repeats itself after an interval of time is called vibration or oscillation. Vibratory system, in general, includes a means for storing potential energy (spring or elasticity), a means for storing kinetic energy (mass or inertia), and a means by which energy is gradually lost (damper). During vibrating, the object will be shifted out the original position and come back like a pendulum. 3As complex as vibrating compact system configuration, an initial step defining how many mathematical particular moving parts that make simple the solutions are very important. Noise and vibration on maritime vessels are not the same but they have the same origin and come in many forms. The methods to handle the related problems are similar, to a certain level, where most shipboard noise problems are reduced by controlling vibration.

Future Plan

The department of NAME has a roadmap to achieve modern and technologically updated laboratory equipment for the researchers and students of the department. The plan is to house specialized laboratory facilities which include:

- A towing tank for model tests of models of ships and offshore structures in calm water and in waves, as well as in shallow water with current.
- A Model Shop for projects and for towing tank model and experiment manufacture.
- The Structural Test System, a 20 ft x 20 ft wide and 10 ft high space frame with computer controlled hydraulic actuators for testing aluminum, steel and composite ship structural components.
- Linux High-Performance Computing Cluster - a modern 82 processor parallel computer for numerical analysis and simulation
- A Marine Engineering Laboratory with programs on ship safety, operations, reliability, maintenance, and performance simulation of propulsion systems.

Conclusion

A good on-campus laboratory is always a top characteristic of MIST. Engineering is a branch of study that involves a lot of experimenting. Every branch of engineering demands the use of a controlled environment such as a laboratory, where the outcome of theories and practices can be produced, tested, and analyzed for further studies. Every student of MIST who aspires to be an engineer has to be familiarized with laboratories.

Laboratories in Naval Architecture and Marine Engineering is crucial for the engineering education. Working in a lab is the first hands-on experience that an engineering student gets in his or her career. The amount of successful practical applications carried out by a student in engineering labs helps them become more confident about their knowledge and skills.

Hence, laboratories play a crucial role in the all-round development of engineering students, as well as faculty members. Labs will always be the key part of the educational ecosystem of MIST for years to come.

Author's Brief Biography

Captain M Enayet Kabir, (E), psc, BN has been graduated in Mechanical Engineering from Chittagong University of Engineering and Technology (CUET). He completed his MSc in Mechanical Engineering from BUET. He had his Masters in Defence Studies from National University Bangladesh.

He completed Energy Propulsion Course from France, Naval Command and Staff Course from Royal Brunei Armed Force, Diploma in International Security from Massey University New Zealand, Air Engineering Specialization Course from Indian Navy; Marine Engineering Specialization (Bangladesh), Junior Staff Course, Naval Staff Course (DSCSC, Mirpur), ACAD course from BPATC, Savar, Dhaka.He served as Director of Shipbuilding in Naval Headquarters (NHQ); General Manager in Khulna Shipyard Ltd, Khulna, Staff Officer in UNIFIL Mission, Engineering Officer (EO) onboard Naval ships, Staff Officer at NHQ, OIC in Engineering School of Bangladesh Navy, GSO-2(Procurement) in Armed Forces Division (AFD).

He was Instructor Class 'A' and Instructor Class 'B' in Mechanical Engineering department of MIST; Instructor and OIC of engineering training school of Bangladesh Navy, Training Commander of BNS SHAHEED MOAZZAM, Kaptai. His teaching interest includes Control Engineering in mechanical systems, Machine Design, Internal Combustion Engine and Marine Propulsion. Currently he is working as Senior Instructor in the department of Naval Architecture and Marine Engineering at MIST.

Services provided by NAME Department as Development Partner under Centre for Advisory and Testing Services, MIST

Captain Kaosar Rashid, (E), psc, BN

Military Institute of Science & Technology (MIST) was established with a view to provide quality engineering and higher technical education to Bangladesh Armed forces` personnel as well as civil students and professionals of the country. The institution was inaugurated by Honourable Prime Minister of Bangladesh, Sheikh Hasina on 19 April, 1998. Along with 12 departments, highly professional faculty members, modern infrastructure and adequate testing and lab facilities, MIST by now has emerged as one of the leading engineering universities in Bangladesh.

Six departments of MIST namely Civil Engineering (CE), Environmental, Water and Coastal Engineering (EWCE), Electrical, Electronic and Communication Engineering (EECE), Mechanical Engineering (ME), Naval Architecture and Marine Engineering (NAME) Department and Computer Science and Engineering (CSE) operate Centre for Advisory and Testing Service (CATS-MIST) to provide real-life related practical engineering knowledge to the students of both undergraduate and postgraduate level for attaining OBE system compliance which is one of the prime objectives of the institution. Other objectives of CATS include making provisions for advisory, research and consultancy services including supervision, material testing, making suitable agreement with any person/organization, carry out research, investigation, innovative & development based intellectual studies to meet the demand of the fast-changing technological needs of the society and the nation.

CATS-MIST is equipped with sophisticated, latest technology-based state of the art lab equipment. It is designed to undertake extensive engineering research by the faculties of the institute, pertaining to specific technological needs of the institute itself and providing knowledge-based world class testing and consultancy services to various government, semi-government, non-government organizations, private entrepreneur and industries in the field of engineering projects.

Department of Naval Architecture & Marine Engineering (NAME) started its journey in the year of 2013 with an undergraduate program consisting of 32 students. Within last seven years the department has provided graduation to four academic batches and currently is running four academic batches having almost 150 students. From April 2020, NAME department has also started MSc and PhD in Naval Architecture and Marine Engineering courses along with a vision to develop the state-of-the-art facilities and expert manpower to expand the research and consultancy service providing capabilities of the department. On this premise the outfit, CATS-MIST (NAME) started its journey in 2016 with a view to provide knowledge-based world class technical services to satisfy the needs of individuals, industry and society. The vision of the outfit is to excel in providing research, investigation and development based intellectual and technical services to meet the demand of the fast-changing technological needs of the society and the nation.

A group of highly professional faculties consisting of six professors, eight associate professors, eight assistant professors and four lecturers deliver their expertise to the students of MIST as well as the industrial fields of the nation through CATS-MIST (NAME). These faculties are drawn in from military, industry and reputed academic fields having diverse educational qualification and background.

So far CATS-MIST (NAME) has been involved with three of the government projects of which two had already been completed and the other one is about to be completed by the end of this year. Our strengths lie on providing consultancy services as per requirements with the highest level of technical confidence, honesty and sincerity.

Recently CATS-MIST (NAME) has completed several consultancy projects of maritime industry in Bangladesh. The main responsibility was to prepare a feasibility report for the patrol and pilot vessels. Besides this, the NAME department conducted a 20-inch dredger and a 26-inch dredger consultancy project. There were some other responsibilities i.e. preparing the technical specification and cost estimation report of these special types of watercrafts. Currently, department of NAME is doing the inspection and supervision work for the construction of 112 watercrafts of BIWTA including 20 dredgers and special type of excavation equipment. The summarized format of the consultancy works of NAME department are given below:

Serial No	Service	Organization (Client)	Position of NAME Dept of MIST	Duration
1.	Consultancy Services for the procurement of Cutter Suction Dredgers of different sizes, various ancillary vessels and other accessories along with design of infrastructure for dredger base like office building, ware house, dormitory etc. in 6 (six) areas.	BIWTA (Bangladesh Inland Water Transport Authority)	Consultant	Dec 2016 - Ongoing
2.	Feasibility study for Procurement of 01 no. High Speed Pilot Boat and 01 no. High Speed Patrol Boat	CPA (Chittagong Port Authority)	Consultant	Feb 2017 – May 2018
3.	Consulting Service for Procurement of 01 no. 26 inches and 01 no. 20 inches Cutter Suction Dredger with other ancillary Crafts (02 no. Crane Boat + 02 no. House Boat) and Accessories.	CPA (Chittagong Port Authority)	Consultant	Feb 2017 – Sept 2018

The first Project is concerned about the procurement of 20 nos. of dredgers, 92 nos. of ancillary vessels, 14 types of ancillary items & other accessories along with construction of infrastructure for dredger base like office building, warehouse, dormitory etc. in 6 (six) areas, which was adopted by BIWTA through the approval of Ministry of Shipping under Annual Development Programs of Bangladesh.

The whole project work is divided into two parts, namely Part-A (Construction of infrastructure for dredger base like office building, warehouse, dormitory etc. in 6 (six) areas) & Part-B (Consulting services for the procurement of different sizes cutter suction dredger, ancillary vessel and other accessories). Part-A consists of civil works for six dredger stations and Part-B includes procurement, construction etc. works for 112 vessels & other ancillary items.

The second & third project dealt with the consultancy services to Chittagong Port for procurement of high-speed pilot boat, 26 inches and 20 inches Cutter Suction Dredger with other ancillary Crafts. CATS- MIST (NAME) had submitted the feasibility study report, cost estimation report and tender document for the procurement of high-speed boat and pilot boat for CPA by June of 2017. The project was declared to be finished by CPA at around May of 2018.

However, besides these works, NAME department are also rendering all types of technical support to Bangladesh Army by supervising the design & drawing and construction works of various vessels like LCT (River worthy), LCT (Sea worthy), TCV, BK Barge, Pontoon, High speed boats etc. Following are some of the projects where MIST provides their expert opinions on:

Ser	Project Title	Organization
1	Procurement of Vessel Type "A" (LCT) (sea-worthy).	14 Independent Engineer Brigade, Dhaka Cantonment
2	Procurement of Vessel Type "B" (TCV) (sea-worthy).	Engineer Directorate, Engineer-in-Chief's Branch, Army Headquarters
3	Procurement of Out Board Motor (OBM) 300 HP (150x2) boat with accessories.	Engineer Directorate, Engineer-in-Chief's Branch, Army Headquarters
4	Procurement of Broad Keel (BK) Barge.	14 Independent Engineer Brigade, Dhaka Cantonment
5	Procurement of Vessel Type "A" (LCT) (river-worthy).	14 Independent Engineer Brigade, Dhaka Cantonment
6	Procurement of Vessel Type "C" Landing Craft Vehicle & Personnel (SCVP).	14 Independent Engineer Brigade, Dhaka Cantonment
7	Procurement of Reconnaissance & Survey Craft.	14 Independent Engineer Brigade, Dhaka Cantonment
8	Procurement of Salvage & Recovery Craft.	14 Independent Engineer Brigade, Dhaka Cantonment
9	Procurement of Vessel Type "C" (Commander Vessel)	14 Independent Engineer Brigade, Dhaka Cantonment

Ser	Project Title	Organization
10	Procurement of Vessel Type "D" (river-worthy).	Engineer Directorate, Engineer-in-Chief's Branch, Army Headquarters
11	Procurement of Motor Tug (MT).	Padma Multipurpose Bridge Project, Engineer Directorate, Engineer- in Chief's Branch, Army Headquarters
12	Procurement of 02xMetal Shark Aluminum Boat (Sea Horse).	Padma Multipurpose Bridge Project, Army Headquarters, Engineer-in-Chief's Branch, Engineer Directorate
13	Preparation of technical specification and design for the procurement of Hilsha Fish Research Vessel.	Bangladesh Fisheries Research Institute, Riverine Station, Moishadi, Chadpur

Few snapshots of our consultancy works are attached below:

Construction undergoing of Cutter Suction Dredger in Karnafuly Dockyard, Chittagong

Construction undergoing of Cutter Suction Dredger in Karnafuly Dockyard, Chittagong

Operation of Cutter Suction Dredger near Padma Bridge, Shimulia

Inspection of Cutter Suction Dredger near adma Bridge, Shimulia

Inspection of Cutter Suction Dredger in Barisal with BIWTA Team

We are open for the following consultancy services to Bangladesh Army, Navy, Coast Guard, Shipyards and any other government organizations:

- Supervision of Design and Drawing of Ship
- Supervision of Constructions of different types of Dredgers
- Supervision of Constructions of different types of Ships
- Preparation of Proposals for Construction of different types of ships
- Technical advice for Marine construction
- Feasibility study of different types of ships and boats
- Technical advices and consultancy services for Ship borne portable and fixed firefighting systems.

Author's Brief Biography

Capt Kaosar Rashid, (E), psc, BN has been graduated in Naval Architecture and Marine Engineering from BUET in 2007. He completed his MSc in Naval Architecture and Marine Engineering from BUET in 2015. Capt Kaosar did Marine Engineering Specialization (Bangladesh and India), Marine Engine Simulator Course (India), Post graduate Diploma in Marine Engineering, Junior Staff Course, Naval Staff Course (DSCSC, Mirpur) and Masters in Defence Studies (Bangladesh University of Professionals (BUP). He served as Deputy General Manager in Khulna Shipyard Ltd, Khulna, Engineering Officer (EO) onboard Naval ships (Small, Medium, large), Staff Officer (plans) at NHQ, Dhaka and OIC in Khulna Shipyard, Dockyard & Engineering Workshop Limited. He also worked as Instructor Class 'A' in NAME dept. and Instructor Class 'B' in Mechanical Engineering dept. in MIST Engineering Instructor in Bangladesh Marine Academy and Instructor in Engineering Training School of BNS SHAHEED MOAZZAM. Currently he is working in the department of Naval Architecture and Marine Engineering in Military institute of Science and Technology as Senior Instructor. His teaching and research interest include Environmental Pollution by Marine Vehicles, Control of Marine Accidents, Propulsion Efficiency, and Offshore Structure Analysis.

Computer Softwares in Aid to Ship Design: Tools for Modern Naval Architects

Muhammad Rabiul Islam, PhD, EME

Abstract

Recent developments of computerization and automation in the ship design spiral process are discussed with specific examples and descriptions. An example of standard software package for a Naval Architecture and Marine Engineering department is shown. Students as well as professionals may have a complete scenario of different software that are used in Naval Architectural field from this article. The sources of most of the data and images that are incorporated in this article are internet especially the software specific websites.

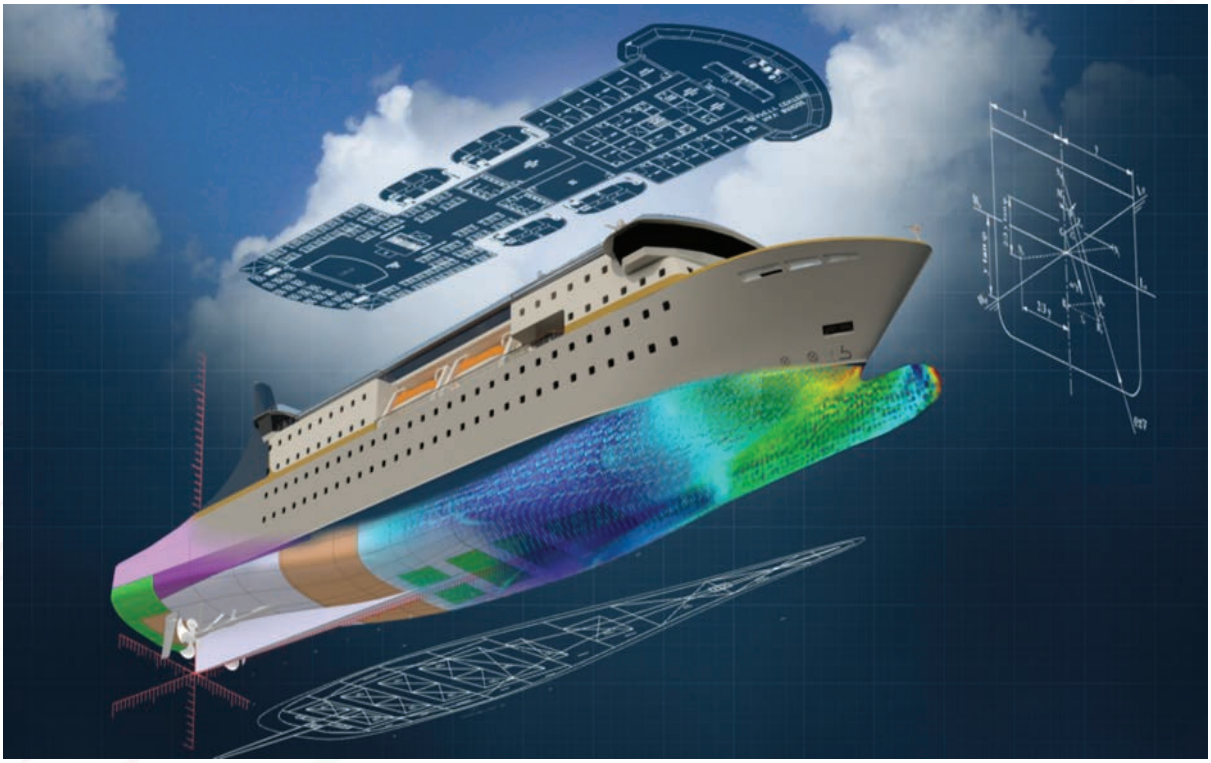


Figure 1: Illustration of computer aided ship design

Introduction

Ship design engineering is officially termed as 'Naval Architecture and Marine Engineering' in Bangladesh. It is one of the oldest, broadest and specialized engineering disciplines. Engineers of this discipline design the largest manmade objects (around 500 meter in length) that move and design some of the most complex systems like aircraft carriers or nuclear submarines. Design projects that naval architects undertake include underwater vessels, warships, sailboats, unmanned robotic craft and advanced sea skimming vehicles. Naval architects have also been involved in the design of many other types The creation of a functional and effective ship design draws on the

expertise of multiple disciplines. While these all work in a synergetic relationship throughout the entire design process, it is notable that one area of knowledge in particular forms the foundation of ship design. This is Naval Architecture[1].

Role of Software in Engineering

Software is a dominating factor in the development of complex systems of engineering. It has a crucial role in the performance of the manufactured product, cost of development and elapsed time of development. An improved understanding of the role of software enables the engineers and the developers to integrate the software development better. Over the past several decades, the use of software in engineering has grown significantly. Nowadays, it is hard to find a field of engineering that does not rely on one or more specialized computer software. Design engineers across all disciplines learn early on how to use the preferred program for their field. It is impossible today to get an engineering degree without learning at least a few of the more common software like MATLAB or AutoCad. These tools have become essential to today's engineers and represent a significant portion of their education and training[2].

Software in Naval Architecture and Marine Engineering

The following enunciations[3] of lead professionals in the field suffice to explain the contribution of different related software in the field of Naval Architecture and Marine Engineering.

- "Software has impacted the full spectrum of the maritime industry – design, construction and ship management. From the design side its primary benefit is to enable the ship designers to optimize ships both from the perspective of efficiency, and to optimize the weight, speed and power of the vessel as well as reliability and safety," - R. Keith Michel, president of The Webb Institute and former chairman of Herbert Engineering Corp., a provider of ship design and engineering services.
- "I think software is crucial for any large-scale design or construction process. If a facility doesn't adapt, it will be out of business," - Prof. Richard Neilson, dean at The Webb Institute.
- "I haven't seen a shipyard work without software. I think creating products of a size today like big cruise liners, is not possible without design and construction software," - Benjamin Mesing, graphics researcher at German research institute Fraunhofer IGD.
- "We've gone from piles of paper to doing it all on your computer," - RDML Joe Carnevale (Ret), senior defense advisor for Shipbuilders Council of America (SCA).

Software that are used in design spiral process[4]

Initial Design

- Aveva Marine Initial design (Previously Tribon);
- Lines (Not used now a days);
- Stability Module;
- Autocad;

[1] C-Job. Dedicated partner for ship owners and shipyards, UR: https://www.c-job.com
[2] Engineering 360. Powered by GlobalSpec, URL: https://insights.globalspec.com
[3] Keefe, P. (2014): Soft Solutions (Tech morphs design loft into loftier designs), Maritime Reporter and Engineering News, pp.67-71
[4] Quora. A place to gain and share knowledge, URL: https://www.quora.com

- Napa (For surface modeling and related calculations);
- Maxsurf modeler;
- Rhino (Powerful surface modeler with tons of features);
- Autohydro (For stability);
- Maxsurf stability;
- Freeship;
- GHS;
- Paramarine;
- Delftship.

Production/Detailed Design

- Aveva Marine (Separate modules for structural modeling, piping, electrical, nesting, planning, outfitting and simulation);
- FORAN;
- NAPA STEEL;
- NUPAS CADMATIC;
- Ship constructor (Works on top autocad)
- Maxsurf structure (Generally used for small vessels).

Resistance Calculation (Hydrodynamics)

- Maxsurf resistance (Based on empirical methods);
- Shipflow (full scale cfd);
- Ansys fluent (full scale cfd);
- StarCCM (full scale cfd);
- OpenFOAM;
- V-Shallo;
- FreSCo+;
- Altair acusolve.

Sea Keeping & Manoevouring

- StarCCM;
- OpenFOAM;
- Ansys Aqwa;
- WAMIT;
- Maxsurf seakeeping (Limited functionalities);
- OrcaFlex;
- Octopus.

Structural Analysis

- Staad Pro;
- Poseidon;
- Ansys;
- Abaqu;s
- Code Aster;
- Patran/Nastran;
- LS Dyna.

General Purpose Software

- Matlab;
- Python;
- Excel.

Apart from the proprietary software, classification societies have their own software for different calculations.

NAPA by Napa Ltd, Helsinki, Finland

Proven benefits of the NAPA 3D model[5]:

- o Enables a single source for design information which ensures that the data is always up to date, enabling reliable results in analysis;
- o Using a purpose-designed 3D model ensures more accurate results in earlier design stages;

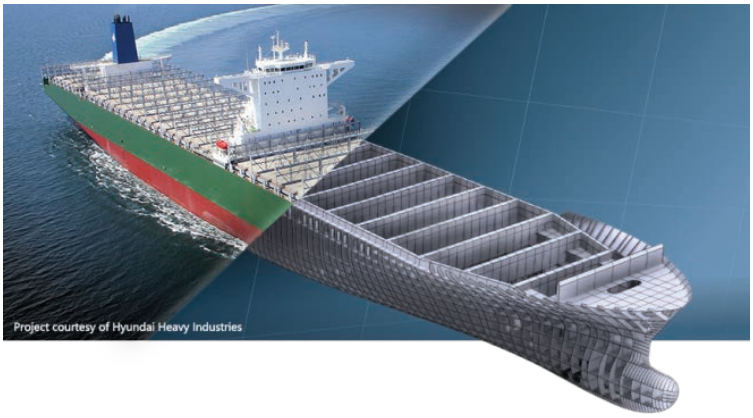


Figure 2: Illustration of Hyundai Heavy Industries project by NAPA

- o Excels in design change and automation;
- o Ensure that the support for relevant rules is available and up-to-date;
- o Can provide analysis of collected data for ship operation, which means naval architects can create designs that better fits the real-life usage of the vessel.

MAXSURF by Bently Systems, Incorporated, US[6]

MAXSURF Naval Architecture Software provides integrated tools for hull modeling and optimization, comprehensive stability, motions & resistance prediction, structural modeling, structural analysis, and export to vessel detailing. It is efficient as it does the followings:

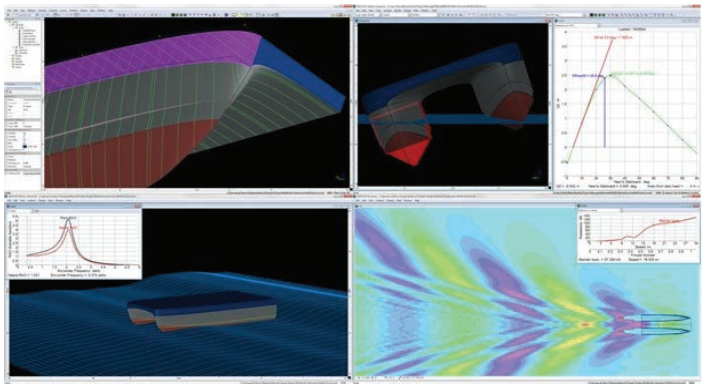


Figure 3: Maxsurf is an integrated Naval Architectural software for all types of vessels.

[5] NAPA. Software Company in Helsinki, Finland, URL: https://www.napa.fi
[6] MAXSURF. Bently Systems, Incorporated, US, URL: https://www.maxsurf.net

- o Ensure hull fairness and suitability for construction;
- o Improve design with accurate performance prediction;
- o Verify compliance with stability regulations;
- o Optimize vessel design for competing requirements;
- o Collaborate with others and exchange data without errors;
- o Easy to learn and master, with intuitive user interface.

ShipConstructor by SSI, Canada[7]

The mission of SSI is to support and deliver increased productivity for the world's shipbuilding industry by bridging the gap between tradition and technology.

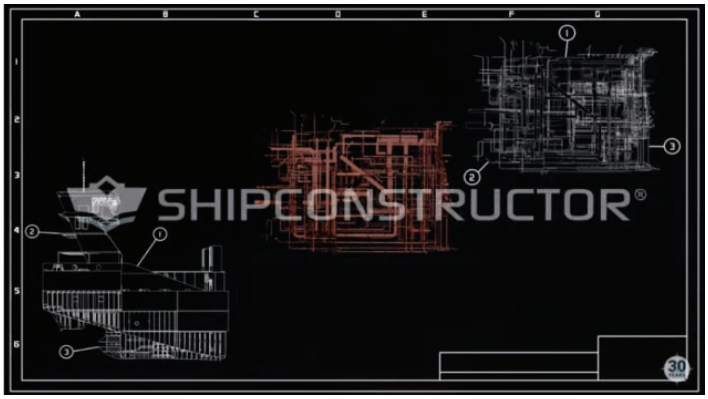


Figure 4: Ship Constructor is a portfolio of AutoCAD based CAD/CAM product.

ShipConstructor designs specifically for the engineering and construction of the hull, internal structure and outfitting of the vessel. It is an industry specific solution. The main divisions are:
Hull/Structure Products
Hull, Structure, Weld Management, Nest, NC-Pyros

Outfitting Products
Pipe, HVAC, Electrical, Penetrations

WorkShare Products
WorkShare teams, WorkShare Transfer, WorkShare Project, WorkShare Design, WorkShare Model

General Products
ShipExplorel, MarineDrafting, Equipment, Report, ProductHierarchy.

AVEVA Marine by AVEVA Group, UK
AVEVA Marine maximizes project efficiency from design to execution. AVEVA's digital ship development approach empowers owner/operators to build a true 3D digital twin of their marine asset, allowing multi-discipline teams to collaborate in real-time, increasing engineering efficiency, data maturity and a reduction in project schedule.

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[7] ShipConstructor. SSI, Empowering the Business of Shipbuilding,URL:https://www.ssi-corporate.com
[8] AVEVA. Marine Engineering Software & Solutions, URL: https://www.aveva.com

Figure 5: AVEVA Marine is an engineering and design step-change solution

The main four divisions of this digital ship development solution are AVEVA E3D Design, AVEVA Outfitting, AVEVA Hull Design and AVEVA Point Cloud Manager.

A Sample of Standard Software Package for Naval Architecture and Marine Engineering Department

The Boysie Bollinger School of Naval Architecture and Marine Engineering (NAME) at the University of New Orleans (UNO) has been considered as a standard for illustrating a sample software package [Figure 6] that may be maintained by the Department of Naval Architecture. There is a close relationship between the UNO-NAME program and the marine industry . (NAME) at the University of New Orleans (UNO) has been considered as a standard for illustrating a sample software package [Figure 6] that may be maintained by the Department of Naval Architecture. There is a close relationship between the UNO-NAME program and the marine industry .

Design Activity	Software Package
I. Lines Fairing	AutoShip Nautilus AeroHydro FastShip
II. Stability-Hydrostatics	AutoHydro Nautilus GHS HEC
III. Resistance-Propulsion	Auto Power NavCad
IV. Structural Design	AutoBuild ABS Safe Hull MAESTRO
V. Finite Element Analysis	FEMAP GIFTS ALGOR StruCAD
VI. High Speed Craft Design	ABS Rules Lloyds Rules DNV Rules

Figure 6: UNO-NAME design software inventory 1998-1999

Conclusion

Most of the software that are used in different purpose of Naval Architecture and Marine Engineering are mentioned in this article and leading four software are introduced in short. An example of Standard Software Package for educational institute is given. Readers may have an initial idea regarding the CAD/CAM technological development in the field of engineered systems, including land vehicles, airplanes and even spacecraft .

> **"I choose a lazy person to do a hard job. Because a lazy person will find an easy way to do it"**
> **– Bill Gates**

[9] Latorre R., Vasconcellos J.M. (2002): Introduction of Software Packages in Naval Architecture, Marine and Ocean Engineering Courses, Int. J. Engng Ed. Vol. 18, No. 1, pp. 98-105

[10] Latorre R., Vasconcellos J.M. (2002): Introduction of Software Packages in Naval Architecture, Marine and Ocean Engineering Courses, Int. J. Engng Ed. Vol. 18, No. 1, pp. 98-105

[11] United States Naval Academy. Official U.S. Navy Web Site, URL: https://www.usna.edu

Author's Brief Biography

Lt Col Muhammad Rabiul Islam, PhD, EME has been graduated in Naval Architecture and Marine Engineering from BUET in 2003 and has completed his MSc. in Naval Architecture and Marine Engineering from BUET in 2007. He had his Doctor of Engineering from Department of Systems Design for Ocean-Space, Yokohama National University, and Yokohama, Japan in 2011. He is working in the Department of Naval Architecture and Marine Engineering in Military Institute of Science and Technology as Instructor Class 'A' from January 2015. Previously, he worked as Executive Engineer (Naval Architecture) (2011-2014) and Assistant Engineer (Naval Architecture) (2004-2008) in Bangladesh Inland Water Transport Authority (BIWTA). He also served as Instructor (Naval Architecture) is Bangladesh Institute of Marine Technology, Narayanganj and Engineer (Design) Maritime Engineering Services, Shantinagar, Dhaka, Bangladesh. His teaching and research interest include Finite Element Analysis (Liner/non Liner); Machine Vision Technology; NC Programming and NC Machine; Offshore Structure; Ship Stability and Inland Stability Rules; Ship Structure/Steel Structure; Geometrical Effect of Pitting Corrosion.

Application of Computational Fluid Dynamics

Osman Md Amin, PhD

Introduction

Fluid dynamics as an engineering study has a great history of theoretical and practical implications in our everyday life. It provides us with vigorous types of tools to approach with any kind of fluid flow related problems. Maritime sector, which we mostly imagine to be largely consisting of issues related to ships and offshore structures plying in vast ocean and inland waterways, flourishes through implementation of latest technologies in fluid flow related engineering problems. One of these latest technologies, where fluid dynamics meets numerical techniques, can be termed as Computational Fluid Dynamics (CFD). Almost all industries have adopted numerical analysis techniques to improve the design and construction standards. Marine Industry, among them, is the early adopter of this technology, which along with other factors have made this industry the true state-of-the-art in nature as we see it to be nowadays. Although the acceptance of CFD in marine applications, partly due to the complexity of simulating free surface flows and the requirement of higher computational power, has lagged behind a bit as compared to other industries[1]. Also, the industry still considers experimental investigation to be more reliable[2]. In this respect, the CFD simulation is carried out at the preliminary design stage to reduce the cost while carrying out experimental investigation at the final stage for verification. CFD not only has impact on the resistance and propulsion related issues in marine hydrodynamics but also it can be used to predict different types of floating body motion dynamics like extreme wave impacts, green sea loads, slamming, sloshing, seakeeping, flooding, coarse-keeping, maneuvering, just to name a few. Also, fields like offshore industry, Green ship technology and blue economy are thoroughly getting explored and investigated by the numerical technique like CFD for preliminary evaluation and optimization of the design of structures involved with those. The property of CFD that allows it to be used on such a wide range of applications is the generality of the method. At the base level CFD does not hold any presumptions about the flow phenomena at hand, such as assumptions about the wave steepness, single-valued free-surface elevation, irrotational flow, small changes in the wetted surface of the hull and so on. This allows the method to be applied to many different problems, although difficulties can be expected in uncharted waters, i.e. phenomena which has not been simulated before.

Fundamental concepts of Computational Fluid Dynamics

In its core, this field of study largely being approached with two fundamental point of views. One is Eulerian approach and the other one is the Lagrangian approach. In Eulerian perspective, the whole domain is observed at a certain instant to investigate the flow parameters (velocity, pressure, density etc.) at every point of the fluid domain. Lagrangian approach considers the observation of each individual particles within the fluid flow to figure out its flow parameters with respect to time. Both of these two points of view are important to understand the characteristics of fluid flow. In this context, the investigations are carried out using some of the well-known tools named Equation

[1] Jasak, H. (2017): CFD Analysis in Subsea and Marine Technology, IOP Conf. Series: Materials Science and Engineering, Vol.276 pp.1-11

[2] Mizzi et al. (2015): HPC and CFD in the Marine Industry: Past, Present and Future, Proceedings of the 3rd International Conference on Exascale Applications and Software, pp.92-97

of Continuity, Momentum equation and Energy equation in two- or three-dimensional fluid domain. Equation of continuity more or less dictates the mass conservation within the domain. Whereas momentum equation formulates the dynamic behavior of the fluid flow considering nonlinearity, viscosity and turbulence within the flow. This momentum equation is a set of dynamic equations, also termed as Navier-Stokes equation – named after the Frenchman M. Navier and the Englishman G. Stokes – who independently obtained the equations in the first half of the nineteenth century[3]. As these equations are nonlinear partial differential equations (PDE), there can be no exact solutions for these equations – which compels us to solve these set of equations along with continuity equation numerically. Another problem with solving flow field parameters from these equations is the closure problem, i.e. the number of variables are larger than the available number of PDE equations to solve. In this context, suitable auxiliary equations from initial and boundary conditions are formulated to solve the closure issue for a particular fluid related problem in numerical fluid dynamics. Energy equation mainly conserves the energy within a fluid domain. Therefore, the field in which computers and numerical analyses are combined to solve fluid related or energy transfer related problems is termed as computation fluid dynamics (CFD). Since our interest is to figure out the flow parameters at every point within the fluid, the values at infinite number of points within a three-dimensional domain becomes impossible to achieve by any means of numerical techniques. In this context, a finite number of points (nodes) within the domain are selected to carry out the numerical simulations, where the PDE equations of equation of continuity and Navier-Stokes equation are discretized for each node into algebraic formulation. Then the achieved set of algebraic equations are solved to get the values of the flow parameters at the nodes. So, in a nutshell, we can say that the objective of CFD is to model the continuous fluids with partial differential equations (PDEs) and discretize PDEs into an algebra problem, solve it, validate it and achieve simulation-based design. Turbulence modeling is another factor which needs to be taken into account for real life fluid flow related problems, as for ships and offshore structures the flow around the bodies are dominated by inertia forces (Reynold's number is of the order of 10^6 to 10^9). In CFD, most popular closure model for turbulence is the Reynold's Averaged Navier Stokes (RANS) equation, which takes into account of the turbulence as the Reynold's stress term[4]. This Reynold's stress term is then modeled in terms of the dynamic equations for turbulence kinetic energy (k) and energy dissipation rate (ε). Most popular RANS turbulence models in maritime sector are k-ω (ω is the reciprocal of ε) and k-ε models. As the computing powers are increasing day by day and parallel & cloud computing technologies are becoming more & more robust, the other closure models like LES (Large Eddy Simulation) and DES (Detached Eddy Simulation) are becoming more effective to be used in real world problems.

Application of CFD in Ship Design

Hull design is the main factor which influences the fuel efficiency, competitiveness, profitability and worth of the ship. Towing tanks have long been serving as a reliable tool for predicting hydrodynamic performances of the ship at sea. However, the cost involved with this experimental technique restricts its utility in the early design stage. CFD simulations on the other hand has long been considered a reliable alternative to towing tank experiments. It provides sophisticated

[3] John F. Wendt (2009): Computational Fluid Dynamics – An Introduction, Springer-Verlag Berlin Heidelberg Publication, Third Edition.

[4] Versteeg, H.K. and Malasekara, W. (2007): An Introduction to Computational Fluid Dynamics – The Finite Volume Method, Pearson Education Limited, 2nd Edition.

numerical techniques to implement innovation and modifications at the early stage of design process. With rapid development of CFD and optimization techniques, the simulation-based design (SBD) concepts have flourished in the early development of design of ships and offshore structures. In this respect, shape optimization of hull structures is nowadays becoming much more relevant through the implication of CFD techniques.

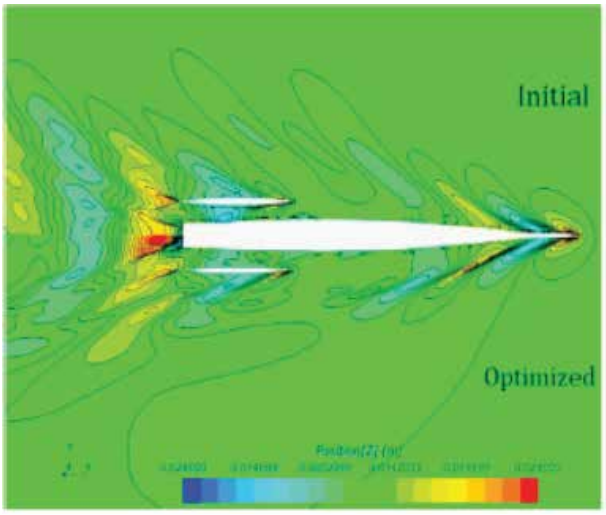

Figure-1: Wave Patterns of the initial and the optimized hull of a trimaran at model speed.

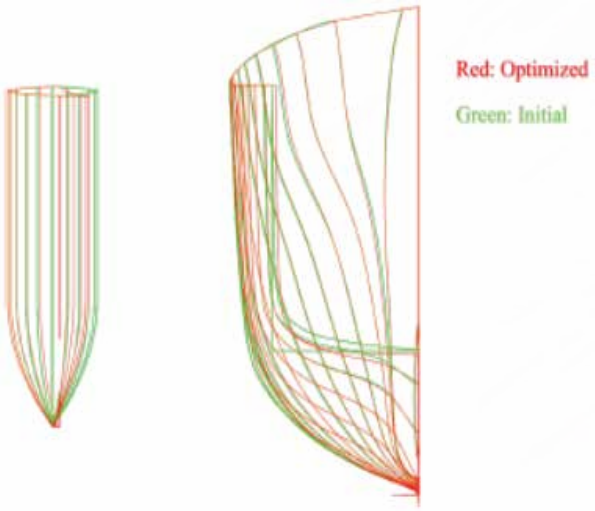

Figure-2: Comparison of body plans between the optimized and initial trimaran hull.

Figure-1 shows the application of adjoint method in optimizing the hull shape of a trimaran using CFD analysis techniques, where a reduction of 6.67% in resistance, with a major modification in side hull (Figure-2) is observed within a limited number of iterations[5]. Other types of approximate methods, like particle swarm optimization method, annealing method along with neural network techniques are becoming popular nowadays to make the application of SBD techniques more practical for ship-shape optimization through the reduction of computational time of typical CFD simulations[6,7].

Resistance and propulsion of Ships

In order to determine the basic hydrodynamic characteristics of a vessel at the early stage of the design two of the basic properties, ship resistance in calm water and the propulsion power need to be investigate. In early days, statistical method, empirical formula like Holtrop and Mennen method[8] or the database of similar vessels were used to predict resistance and propulsion characteristics, where accuracy was a bit concern. That is why in the later stage experiments were carried out in towing tank to verify the results.

[5] Nazemian, A. and Ghadimi, P. (2020): Shape Optimization of Trimaran Ship Hull using CFD-based Simulation and Adjoint Solver, Ships and Offshore Structures, https://doi.org/10.1080/17445302.2020.1827807, pp.1-15

[6] Martinelli, L. and Jameson, A. (2007): An Adjoint Method for Design Optimization of Ship Hulls, 9th International Conference on Numerical Ship Hydrodynamics, pp. 1-10.

[7] Zhang et al. (2017): Computational fluid dynamics-based hull form optimization using approximation method, Engineering Applications of Computational Fluid Mechanics, https://doi.org/10.1080/19942060.2017.1343751, pp. 1-14.

[8] Holtrop, J. and Menne, G.G.J. (1982): An Approximate Power Prediction Method, International Shipbuilding Progress, doi: https://doi.org/10.1007/s13398-014-0173-7.2.

This process has been replaced with CFD simulations nowadays in the early design stage to calculate the resistance in calm water with reasonable accuracy. Although for full scale simulations CFD requires at least 100-300 core hours of computational requirement to keep accuracy within 3% as compared to the experimental results[9]. Also, a high level of experience is required to carry out mesh generation, numerical setup and post processing of the result. Simulating self-propulsion points on the other hand require more computational power to achieve full resolution of the geometrical representation of rotating propeller. These tests are required to determine the shaft power delivered to propeller at certain load condition and speed.

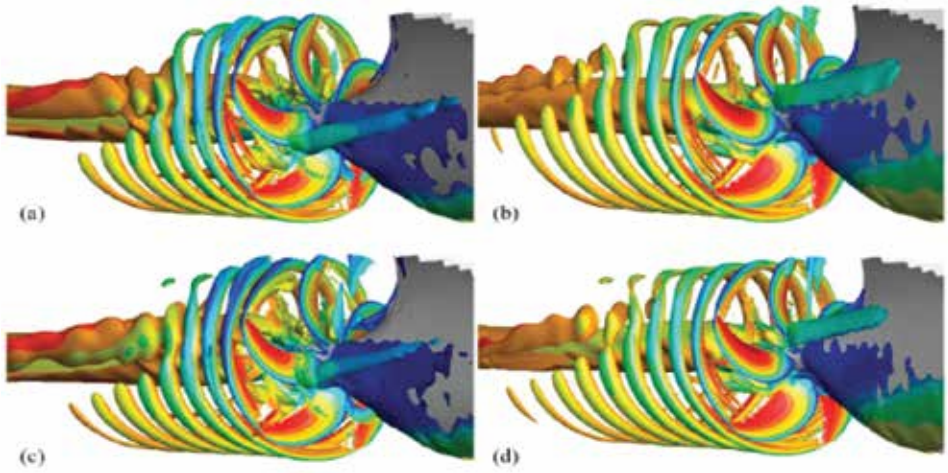

Figure-3: Instantaneous iso-surface of non-dimensional Q-criterion: a) model-scale with double-model, b) full scale with double-model, c) model scale with VOF model, d) full-scale with VOF model

A typical self-propulsion CFD simulation with an actuator disc model takes a similar amount of CPU resources comparing to calm water resistance simulation, but it takes more time and effort to set-up. Figures 3 shows a self-propulsion simulation of a bulk carrier, where the tip vortex generation by propeller were compared for both model and full scale considering free surface effect. While considering Volume of Fluid (VOF) method for free surface simulation, the tip vortex is found to be more stable in nature[10].

Investigation on Seakeeping Performance of Ships

Investigation of hydrodynamic characteristics of ships under waves have a long history of its dependency on the potential flow approach in numerical simulation regime. However, within last two decades CFD has gradually taken its place in simulating these dynamic behaviors through the cost of high computing facilities; as in a typical full-scale ship simulation the mesh may require tens to hundreds of millions of grid points. Free surface, which is the interface between air and water, in CFD is mostly been calculated by two of the methods named VOF approach[11] and the Level Set

[9] Gatin, I. (2019): CFD in the marine Industry: today and tomorrow, online article, link: https://thenavalarch.com/cfd-in-the-marine-industry-today-and-tomorrow/.

[10] Sun et al. (2020): Numerical Analysis of Full-Scale Ship Self-Propulsion Performance with Direct Comparison to Statistical Sea Trial Results, Journal of Marine Science and Engineering, Vol.8, issue.24, doi: http://dx.doi.org/10.3390/jmse8010024.

[11] Ubbink, O. and Issa, R.I. (1999): A method for capturing sharp fluid interfaces on arbitrary meshes, Journal of Computational Physics, doi: https://doi.org/10.1006/jcph.1999.6276.

method[12]. Both of these methods, with their pros and cons, have place in different simulations techniques in naval hydrodynamics. VOF method is very conservative - means the ratio of air and water is well preserved within the flow; which is very much required to simulate free surface behaviors in wave impacts, green water effects, sloshing etc. The disadvantage with this method is the numerical smearing, which means during simulation the thickness of the interface becomes unexpectedly large to impair the accuracy of the result. Although there are several techniques to compensate for the severity of the smearing, the better alternative to use in this case is the Level set method, which is used very frequently in simulations like resistance, seakeeping, self-propulsion of ships to keep the free surface relatively smooth. Level set method on the other hand is non-conservative, meaning some loss/gain of fluid in flow may be expected in simulation violating the equation of continuity. These techniques along with other numerical methods in CFD provides with the flexibility to produce reasonable results in predicting 3-Dof motions along with added resistance under waves. Some of the flow phenomena like vortex shedding, cavitation phenomena, slamming etc. which are difficult to observe through experiment are well predicted by these numerical methods. For example, the bow wave generated by KVLCC2 tanker at an oblique wave cannot be predicted well by potential flow theory as shown in Figure-4, whereas the CFD is simulating the phenomenon of the flow dynamics surrounding the ship hull with quite reasonable accuracy[13]. Verification and validation of results are important factors in uncertainty analysis of CFD simulations, where the absence of experimental data can be to some extent compensated for by systematic verification study[14].

Prediction of Maneuvering Characteristics of Ships

Maneuvering simulation requires the 6-Dof motion simulation including the rudder and propeller interactions with the hull. The mathematical models available to simulate trajectories of the different maneuvering motions like zig-zag, turning, spiral etc. are limited in simulating 3-dof motions[15]. In this respect, CFD provides with the means to simulate all 6-dof motion along with rudder and propeller dynamics for different maneuvering simulations.

Although the simulation requires a significant amount of effort and know-how to first prepare the mesh and then to set-up the required methods and later do post-processing of the results. Also the number of grids in the mesh requires to be in the scale of tens of millions in number. All these factors combined with wave effects make the whole simulation process quite complex and computationally intensive. In this respect, most of the maneuvering simulations are carried out using overset grids, where each element of the ship is designated with separate domain along with grid systems and while all these domains are moving, the meshes interact with each other to update the overlapping node positions using interpolation techniques[16].

[12] Sussman, M. (1994): A Level Set Approach for Computing Solutions to Incompressible Two-Phase Flow, Journal of Computational Physics, doi: https://doi.org/10.1006/jcph.1994.1155.

[13] Seo et al. (2021): Experimental and Numerical Analysis of Wave Drift Force on KVLCC2 Moving in Oblique Waves, Journal o Marine Science and Engineering, Vol.9, issue.136, doi: https://doi.org/10.3390/jmse9020136.

[14] Simonsen, C.D. and Stern, F. (2003): Verification and Validation of RANS Maneuvering Simulation of Esso Osaka: effects of drift and rudder angle on forces and moments, Computers and Fluids, vol.32, pp.1325-1256.

[15] Yasukawa, H. and Yoshimura, Y. (2015): Introduction of MMG Standard Method for Ship Maneuvering Predictions, Journal of Marine Science and Technology, vol.20, pp.37-52.

[16] Shih, T.I-P. (2002): Overset Grids: Fundamentals and Practical Issues, 20th Applied Aerodynamics Conference, AIAA 2002-3259.

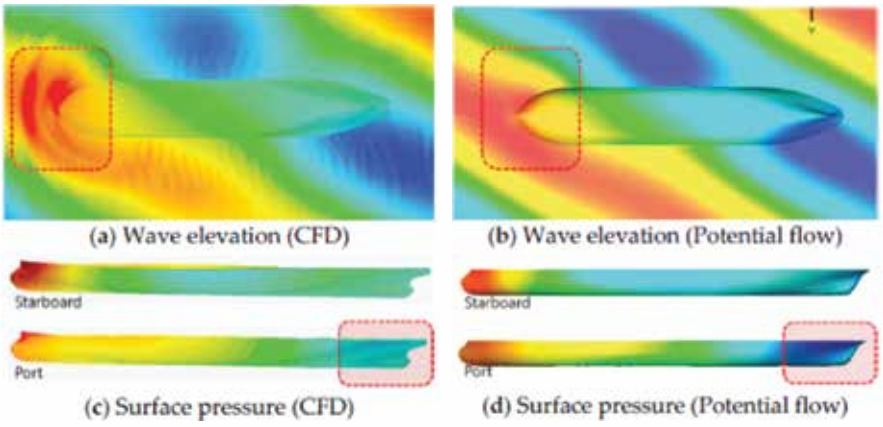

Figure-4: Wave elevation and surface pressure on KVLCC2: a) CFD, b) Potential Flow

A typical overset grid system for a DTMB naval ship while turning[17] is shown in Figure-5, where the free surface elevation during turning is shown in Figure-6. The maneuvering simulations for estimating the hydrodynamic derivatives in calm water has become popular with good agreement with experimental results, both in shallow and deep-water condition[18]. Turning circle simulations with single and twin screw are also nowadays possible with reasonable agreement. Free running simulations for zig-zag maneuver in waves has been reported recently for various wave conditions[19] with reasonable results.

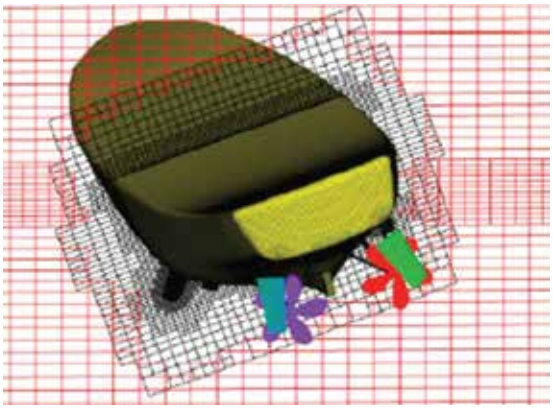

Figure-5: Overset Grid of DTMB Naval Ship

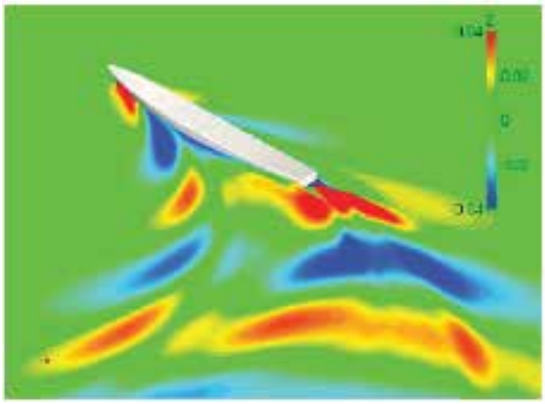

Figure-6: Free surface elevation for DTMB model during turning simulation

Green Ship Technology

The concerns associated with the world shipping industry are the environmental issues as well as the increase of the high price of fuel oil. In spite of being the most efficient modes of global transportation compared to other modes like air and roadways, the shipping contributes to the emission of CO2, NOx, and SOx at about 2–3%, 10–15% and 4–9% per year, respectively. If it

[17] Shen Z. et al. (2014): RANS simulations of free maneuvers with moving rudders and propellers using overset grids in OpenFOAM, SIMMAN workshop on Verification and Validation of Ship Maneuvering Simulation Methods, source: Google Scholar.

[18] He S. et al. (2016): Manoeuvring prediction based on CFD generated derivatives, Journal of Hydrodynamics, vol.28, issue.2, pp. 284-292.

[19] Wang, J. et al (2018): Numerical simulations of zig-zag maneuvering of free running ship in waves by RANS – overset grid method, Ocean Engineering, vol.162, pp.55-79.

continues this way, the amount of global CO2 emission can be increased up to 250% within the year 2050[20]. The reduction of fuel consumption can be achieved by introducing various methods such as Liquefied natural gas (LNG) fueled propulsion, renewable energy utilization (using wind & solar power), improved design (optimized hull form design, highly efficient propeller design, bulbous bow optimization), various energy saving devices (waste heat recovery system, NOx & SOx reduction devices), use of advanced anti fouling paint and optimum weather routing[21]. A combined approach of these aspects will surely advance the industry toward zero emission and greener shipping. Among the various fuel-efficient technologies available to face these challenges, wind-based technologies are the ones having the potential for double-digit fuel savings as well as reduction of the Green House Gas (GHG) emissions. Various wing sail ship technology concepts of both soft sails and rigid sails have also been developed in recent years. OCIUS Technology claims that without modifying a modern tanker or bulker's primary propulsion system, a retrofitting opening wing sails to can save 20–25% on cross-equator shipping routes and 30–40% on transatlantic shipping routes[23].

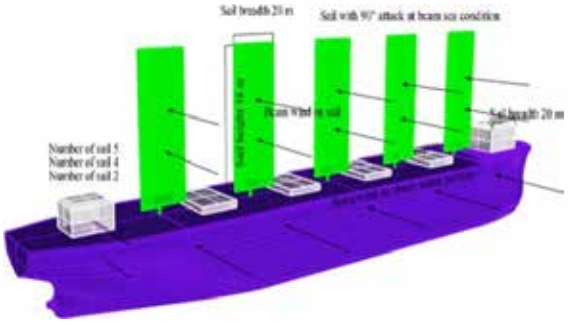

Figure-7: Hard-sail based Wind propulsion technology modeled on a Bulk Carrier

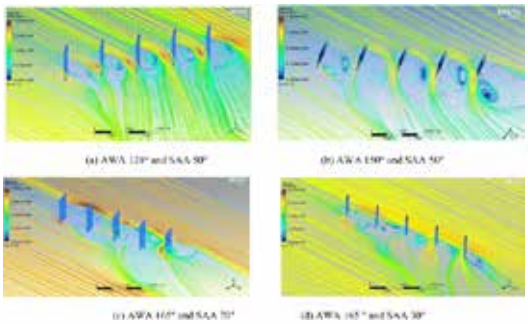

Figure-8: Streamlines around sails at different AWA and SAA

Full-scale tests showed that kites used together with conventional engines could enable an annual saving of up to 35% although it has difficulties of in launching and landing as well as the requirement of the wide air space . Enercon, which deals in wind energy generation and technology launched Flettner-rotor powered cargo ship named the E-Ship-1 in 2008 and it is reported that this device helped to reduce fuel consumption by 25% compared to conventional systems[24]. CFD simulations were carried out to find out the interaction between the sails at different Apparent Wind Angle (AWA) and Sail Angle of Attack (SAA) in reducing thrust requirement of a Bulk carrier with hard sails (Figure-7) through the reduction of 20% break power has been depicted in Figure-8[25].

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[20] IMO (2014) Third IMO GHG Study 2014 – Final Report. The International Maritime Organization (IMO), London, United Kingdom. IMO Technical Report No MEPC 67/INF.3.

[21] Mofor L, Nuttal P, Newell A (2015): Renewable energy options for ship–Technology Brief. International Renewable Energy Agency (IRENA), Abu Dhabi, United Arab Emirates. Technical Report.

[22] Nuttall P, Newell A (2015): Transitioning to Low Carbon Shipping Module Sustainable Sea Transport Solutions for SIDS: Pacific Island Countries Case Studies: United Nations Conference on Trade and Development (UNCTAD), Geneva, Switzerland. Available at http://unctadsftportal.org/wp-content/uploads/2016/08/PRINT-2a-Sea-Transport-in-the-Context-of-SIDS.pdf [Accessed on April 10, 2021]

[23] Viola IM, Sacher M, Xu J, Wang F (2015) A numerical method for the design of ships with wind-assisted propulsion, Ocean Engineering, vol. 105, pp.33–42.

[24] Enercon Wind Company (2013) Enercon E-ship 1: a wind-hybrid commercial cargo ship. In Proceedings of the 4th Conference on Ship Efficiency. Hamburg, Germany, pp. 23–24.

[25] Hussain, M.D. and Amin, O.M. (2021): A comprehensive analysis of the stability and powering performances of a hard sail assisted Bulk Carrier, Journal of Marine Science and Application, doi: https://doi.org/10.1007/s11804-021-00219-w.

Hydro-elasticity of Ships

Hydroelasticity of ships takes account of the effects of mutual interaction between wave induced loads and elastic forces acting on the structure to assess the hull structural strength. Although first proposed in the field of aerodynamics, hydroelasticity theory has been widely developed in the Naval Architecture community since the 1970s[26]. Increasing demand for larger and higher speed ships has dictated the need for study of hydroelasticity of ships ever more during the hydrodynamic and wave load calculations on the ship structure. The 3D hydroelasticity theory, which is the combination of 3D potential flow theory and the 3D structural finite element method (FEM), has so far been the comprehensive tool for the prediction of ships hydro elastic responses[27]. CFD, because of its immense computational power and time cost, still in its early stage to be practical in this sort of engineering problems. The influence of different levels of nonlinearity involved with hydroelasticity in case of predicting slamming impact forces and resulting whipping stresses makes the application of CFD more prone to error in case of irregular wave situations unless gigantic amount of computational power remains in one's disposal. Although large amounts of effort are on the way to make the application of CFD more fruitful through the application of two-way coupled Fluid Structure Interaction (FSI) methods. Fluid Structure Interaction means the mutual influence of fluid forces and the dynamic response of structures like natural frequencies, damping ratios and mode shapes of vibrating structures in contact with fluid[28]. Studies of FSI and the added mass effect, also known as virtual mass effect, hydrodynamic mass, and hydroelastic vibration of structures, started with Lamb who calculated the first bending mode of a submerged circular plate. One-way coupled CFD and 3D FEM was established by Ley and Moctar[29], to evaluate the natural frequency of the wetted ship hull during whipping stress generation. Although improvement of the method was needed to predict the added mass accurately. In this context two-way coupled CFD and FEM is established by Takami and Iijima[30] to estimate both the whipping vertical bending moment and double bottom bending moment in irregular seaways with quite reasonable accuracy. Figure-9 & 10 shows the mesh used for a 6600 TEU container ship and better prediction of whipping VBM using two-way coupled FSI technique as compared to the experimental data, respectively.

Offshore Industry

Offshore exploration demands the necessity of robust structures either static in shallow waters or semi-submersibles in deep water which can withstand the wrath of mighty storms and severe wave loads of seas. In this context, a significant allowance usually been kept in the design between the

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[26] Bishop, R.E.D. and Price,W.G. (1979): Hydroelasticity of Ships, Cambridge University Press, Cambridge, UK.

[27] Price, W.G. and Wu, Y.S. (1985): Hydroelasticity of marine structures, Theoretical Applied Mechanics, vol.316, pp.311–337.

[28] Kwon, Y.W. and Owens, A.C. (2011): Dynamic Responses of Composite Structures with Fluid-Structure Interaction, Advances in Composites Materials - Ecodesign and Analysis, IntechOpen publishers, pp.337-358.

[29] Ley, J. and Moctar, O. (2014): An enhanced 1-way coupling method to predict elastic global hull girder loads. In: Proceedings of ASME 2014 33rd international conference on ocean, offshore and arctic engineering, San Francisco, United States.

[30] Takami, T. and Iijima, K. (2019): Numerical Investigation into combined global and local hydroelastic response in a large container ship based on two-way coupled CFD and FEA, Journal of Marine Science and Technology, Vol.25, pp. 346-362.

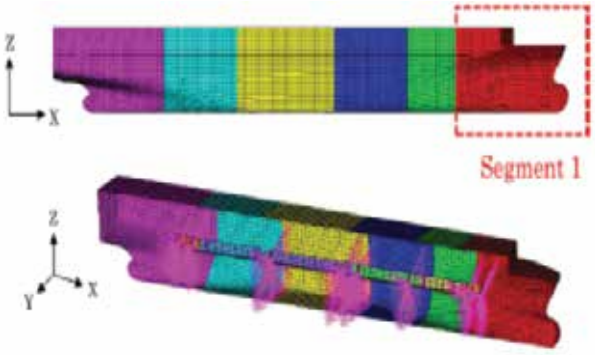

Figure-9: Finite Element mesh used for a 6600 TEU container ship

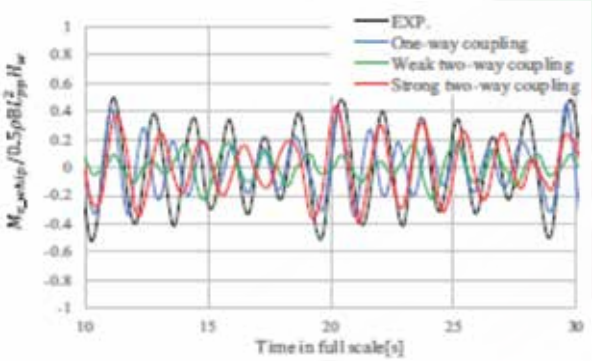

Figure-10: Whipping Vertical Bending Moment

main structure and the water level, which is called air-gap, so that these water impacts do not compromise the global strength and overall stability of the platform. The water loads in local scale may have impact on the safety functions and equipment, but the global load which affects the integrity of the whole platform are of primary interest in investigating offshore platforms in seas.

Because of the complexity of the structures and the requirement of inclusion of severe nonlinearities regarding wave and structure interaction, so far, the application of potential flow theory along with free surface tracking methods are extensively used to predict the wave loads. For achieving further accuracy in predicting the loads, nowadays researchers are vying for CFD analysis techniques for complete assessment of the wave structure interaction effects on offshore platforms. Iwanowski et al[31] performed wave run-up experiments on a three-dimensional model of semi-submersible and compared the results with numerical solution from CFD software COMFLOW to show that computed the averaged pressure was lower for the bottom columns due to higher hydrostatic pressure prevailing there. Application of second order Boundary Element Method (BEM) along with VOF free surface method for a semi-submersible production platform both in moored and fixed condition show that the wave elevation at different points on the platform can be predicted with reasonable accuracy using these techniques[32]. Figure-11 shows the wave run-up simulation of a semi-submersible platform using VOF method in CFD where the maximum pressures due to wave crest underneath the platform's center were simulated to produce results within 4% accuracy as compared to the model test data[33].

Conclusion

CFD is a technology which started during the early years of modern computing hardware development era and continued its reign towards becoming an alternate candidate for the experimental validation in the industries to provide a reasonably accurate result early in the design stage, allowing the designer to try out different options easily and without large financial or temporal costs. Although conducting a CFD simulation is not straight forward and requires an expensive

[31] Iwanowski et al., B. (2009). CFD simulation of wave run-up on a semi-submersible and comparison with experiment, OMAE2009-79052. ASME 28th International Conference on Ocean, Offshore and Arctic Engineering. Honolulu.
[31] Matsumoto et al., F. T. (2013). Wave Run-Up and Air Gap Prediction for a Large-Volume Semi-Submersible Platform, 011302. Offshore Mechanics and Arctic Engineering, vol.135.
[33] Olsson, A. and Tunlid, M. (2015): CFD simulation of wave-in-deck loads on offshore structures, M.Sc. Thesis in Naval Architecture and Ocean Engineering, Chalmers University of Technology.

commercial software along with expertise in the application of the methodologies available in specific fluid flow-based problems. Open-source CFD software are also available but are hard to use and require a specialized user as well.

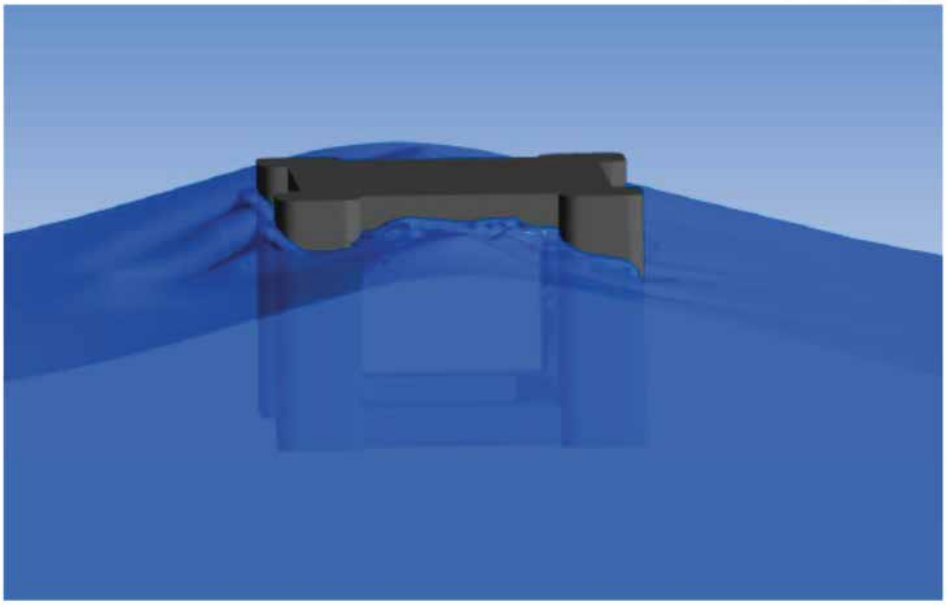

Figure-11: VOF free surface plot for highest peak pressure calculation for a semi-submersible

Despite of these facts, within the last few decades, the technology behind CFD along with the processing speed has improved to a certain degree to take account of simulations of complex problems related to viscous & inviscid flows, turbulent & laminar flows, single & multi-phase flows, thermal/density effects, free surface flow & surface tension, chemical reactions, heat/mass transfer, combustion, fluid structure interaction etc. The two most fundamental fields in marine industry are mostly explored vividly using CFD simulations, which are resistance and propulsion. Six degrees of freedom motion simulation using CFD is still expensive and requires large amount of expertise and experience. In this context, seakeeping and maneuvering simulations using CFD are yet to pervade the literature in maritime sector. Offshore industry, although at early stages were largely dependent on the potential flow simulations for their design investigations, are vying for CFD analyses nowadays. In more complex dynamic problems like wave loads calculation, green water simulations, slamming and others the computation fluid dynamics provide a plethora of opportunity to explore and engage large number of resources to find out complex phenomena which are not possible to be investigated by even experimental methods.

Author's Brief Biography

Lt Col Osman Md Amin, PhD, Engrs has been graduated in Naval Architecture and Marine Engineering from BUET in 2007. Lt Col Osman completed his MSc and PhD in Naval Architecture and Marine Engineering from Osaka University, Japan in 2009 and 2012 respectively. He is working in the Department of Naval Architecture and Marine Engineering in Military institute of Science and Technology as Instructor Class 'A' from January 2015. He also worked as a Senior Lecturer in the School of Ocean Engineering, University Malaysia Terengganu in Malaysia. His teaching and research interest include Applied Hydrodynamics, Computational Fluid Dynamics, Dynamics of Marine Vehicles, Sea-keeping and Ship Maneuvering.

Future Powering Options for Greener Shipping: Alternative Fuels and Technologies

Md Daluar Hussain Sumon

Abstract

Energy efficiency and greenhouse gas (GHG) emission reduction are now important factors in global shipping and shipping contribute approximately 3.0% of global carbon dioxide emission. The maritime sector has established different legislation and agreements to reduce emissions, resulting in the creation of a new concept known as "Zero Emissions". The industry is looking for sustainable global shipping making the vessels energy efficient. Many concepts of improved ship design, alternative fuels and utilization of renewable energies are available. Few preliminary aspects of these concepts are discussed in this paper to give an overview regarding the future powering options for greener shipping.

Keywords: Energy efficient shipping, CO_2 emission, alternative fuels, renewable energy

Introduction

The shipping industry has a vital role in a net zero carbon future. In response to the Paris Climate Accord, the International Maritime Organization has set ambitious goals of halving greenhouse gas ("GHG") emissions by 2050. According to the 4th IMO GHG study, the shipping industry have shared 2.89 % of global GHG emissions in 2018 which has increased from 2.76% in 2012. The emissions of total shipping have increased from 977 million tons in 2012 to 1,076 million tons in 2018 which is 9.6% increase. As a result of increased maritime transportation, as well as challenges in implementing efficient fuel efficiency measures, the contribution to global emission from shipping is likely to rise. It is projected that shipping emissions will increase from about 90% of 2008 emissions in 2018 to 90-130% of 2008 emissions by 2050.[1] The GHG strategy targets to reduce CO_2 emissions 40% by 2030 and 70% by 2050 compared to 2008.[1] Therefore, the design standards for marine propulsion system are becoming increasingly stringent. Not only must optimum propulsive efficiency be met, but also comfort and environmental standards and regulations set by IMO. Because of the increasingly stringent regulatory environment, minimizing emissions from ship has become a pressing issue. Numerous technological and operational methods have been researched by the marine industry in order to make the ship energy efficient and hence to attain specified carbon emission e.g., EEDI standards by IMO. To maintain IMO requirements of Energy Efficiency Design Index (EEDI), the fuel-efficient ships are suggested to reduce CO_2 emission for both international and domestic shipping. The reduction of emission and power savings can be achieved by introducing various methods such as energy saving devices, alternative fueled propulsion, renewable energy utilization, improved hull design, use of advanced anti fouling paint and optimum weather routing.[2] A wide variety of energy-saving technologies are available for ships. These concern primary propulsion and hydrodynamic options in general.

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[1] IMO (2020). Fourth IMO GHG Study – Final Report. The International Maritime Organization (IMO), London, United Kingdom. IMO Technical Report No MEPC 67/INF.3

[2] Hussain MD and Amin OM (2021). A Comprehensive Analysis of the Stability and Powering Performances of a Hard Sail–Assisted Bulk Carrier. J. Marine. Sci. Appl. Vol 3, pp 1-22. https://doi.org/10.1007/s11804-021-00219-w

However, an integrated system engineering approach is required for ships to achieve effective improvements in efficiency and reductions in emissions. This should include all aspects of naval architecture, marine, and control engineering, as well as operational procedures. Furthermore, in order to develop a sustainable and optimal design solution, a systems approach must encompass all stakeholder requirements. With any propulsion option, it is critical to properly assess the overall emission profile of the propulsion method and the fuel used, so that reductions in ship exhaust emissions do not come at the expense of increased harmful emissions in land-based industries that produce either the propulsion machinery or the fuel.

Potential Options of Alternative Fuels

Heavy Fuel Oil (HFO) is the most commonly utilized fuel in international shipping today, accounting for roughly 77 percent of the gasoline burnt in marine engines.[3] This fuel is a byproduct of the refining business, and it has a high energy density, a high carbon content, and a low price. Alternative fuels are needed in the shipping industry for a variety of reasons, including reducing local pollution and complying with existing regulations. Alternative fuels are now widely identified as a significant area of technological advancement for long-term transportation sustainability. LNG, LPG, methanol, biofuel, and hydrogen have been highlighted by DNV as the most viable alternative fuels for energy efficiency ship propulsion.[4] Fig. 1 illustrates the future prediction of using alternative fuels.

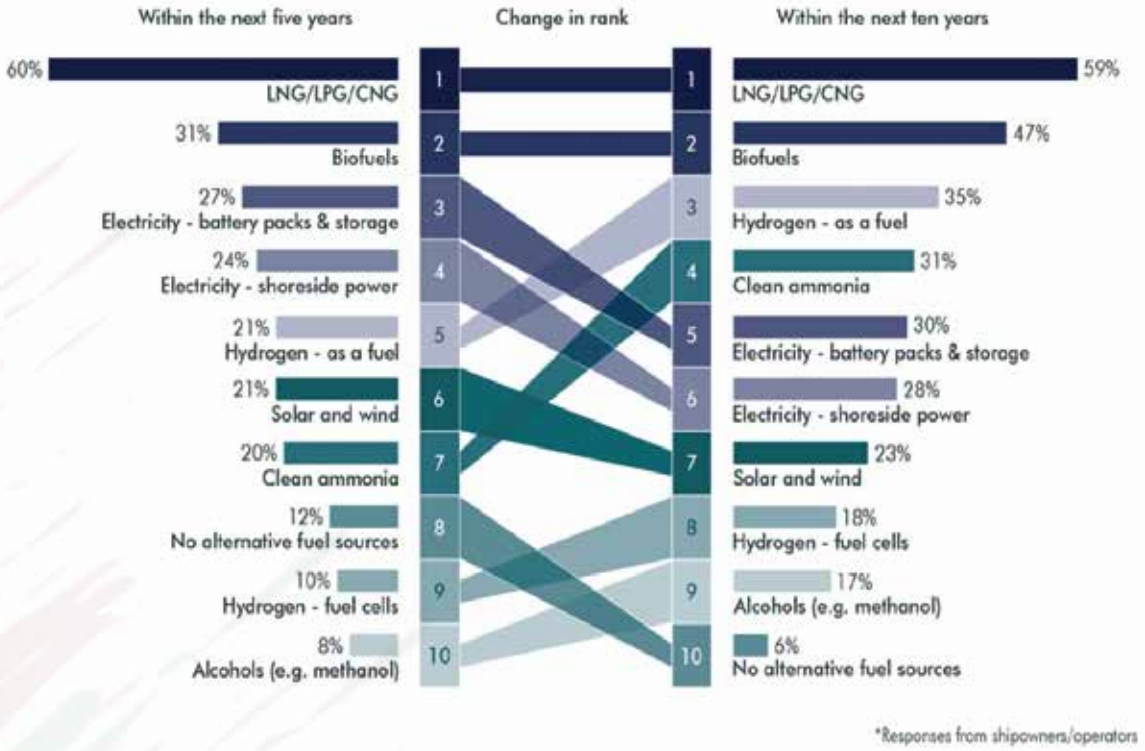

Fig. 1 Alternative fuel sources being considered for future use[5]

[3] https://www.wfw.com/articles/alternative-fuels-what-does-the-future-hold-for-shipping/
[5] https://midc.be/alternative-marine-fuels/

Liquid Natural Gas (LNG) is said to be the future fuel of the shipping industry. LNG fuel aids in the reduction of ship pollution, and combining LNG with diesel oil results in more efficient engine performance and fuel savings. LNG fuel is relatively easy to convert many existing marine engines to burn LNG which brings the major advantages of it. Currently LNG fuel is considerably cheaper than the conventional range of marine fuels.[4]

Liquefied Petroleum Gas (LPG) is considered as an alternative fuel for future ship propulsion which can lower emissions to air compared to conventional fuels, both in terms of greenhouse gas emissions and other pollutants. LPG is currently cheaper than compatible fuel alternatives, based on current fuel price levels. The world's first LPG-fueled vessel successfully set sail in October 2020 and from the sea trial it is confirmed that LPG emits up to 97% SOx, 20% less NOx, 90% less particulate matter (PM) and 20% fewer CO2.[6]

Fig. 2 (a) World's first LNG powered containership Isla-Bella[7]
(b) World's first LPG powered ship BW GEMINI[8]

Methanol is a safe, cost-effective, globally available which can be a potential alternative fuel for shipping that can help reduce emissions and improve environmental performance. Methanol significantly reduces emissions of sulphur oxides (SOx), nitrogen oxides (NOx) and particulate matter, and with the ability to be produced from renewable sources, it provides a way for shipowners to fulfill future emissions regulations without having to invest more money.[9]

Biofuels are potential alternatives to conventional fuels which are derived from the harvesting and processing of various types of biomass or biomass residues that are converted into liquid or gaseous fuels. A number of studies point to sustainable biofuels as one of few options available for deep-sea shipping to achieve the IMO target of reducing GHG emissions. The Meri cargo ship which claims to be the first of its size to use 100% bio-oil.[10]

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[4] DNV.GL Maritime (2019). Assessment of selected alternative fuels and technologies.
[6] https://www.wartsila.com/insights/article/retrofit-highlights-use-of-lpg-as-a-marine-fuel
[7] https://www.marineinsight.com/wp-content/uploads/2015/04/TOTE-1-LNG-Rendering-2015.jpg
[8] https://www.vesselfinder.com/vessels/BW-GEMINI-IMO-9703007-MMSI-235108666
[9] https://www.sspa.se/alternative-fuels/
[10] Mofor L, Nuttal P, Newell A (2015). Renewable energy options for ship–Technology Brief. International Renewable Energy Agency (IRENA), Abu Dhabi, United Arab Emirates. Technical Report.

Hydrogen Fuel cells are another option being developed for alternative propulsion, with pilot projects being launched for large passenger ships. Fuel cell systems for ships are being developed, but they will take years to mature to the point where they can replace main engines. Hydrogen fuel cells are created using renewable energy which is considered as the cleanest fuel. Future maritime applications could make use of liquefied hydrogen. However, due to its poor energy density, hydrogen requires a lot of storage space, which could preclude it from being used directly in international deep-sea ships. There are a variety of ways to use hydrogen to power ships once it has been created. It can be used to power an internal combustion engine, like Hydroville is doing right now.[11] One disadvantage is that burning anything in nitrogen-rich air produces nitrogen oxides, which are substantial air pollutants.

Potential Technology Options of Alternative Ship Propulsions

Renewable energy has the potential to alter the global maritime fleet on many levels and in different ways. Renewable power applications in ships of all sizes include options for primary, hybrid and/or auxiliary propulsion, as well as on-board energy use.10 Potential renewable energy sources for shipping applications include wind, solar photovoltaics, biofuels, wave energy and the use of super capacitors charged with renewables. These sustainable energy solutions can be incorporated into existing fleet retrofits or new shipbuilding and design, with a small number of new ships aiming for 100% renewable power or zero emissions technologies for primary propulsion.10 The current focus of renewable energy application in shipping are discussed in this section.

Wind propulsion, which was the only means of propulsion for ships between the 19th and early 20th centuries prior to the advent of the steam engine. The availability of the heavy fuel oil (HFO) has changed the marine propulsion system significantly although the fluctuating price of fuel was the concern all over the years. However, it appears that the age of wind-powered ships is returning for good, and it could be a critical component in the fight against climate change. Wind-assisted ship propulsion systems appear to have economic and environmental benefits for the shipping industry as they substitute part of the energy ordinarily generated by fossil fuels. Significant number of researches, model test and full-scale trial of the wind assisted ship have been carried out over the past few years. Current wind assisted propulsion technology includes soft sails, fixed wings, rotors, kites and conventional wind turbines.

Traditional soft-sails coupled to yards and masts are a tried-and-true technology for directly harnessing the wind's propelling force. The DynaRig, for example, is currently only used on large sailing yachts. Greenheart's 75 dwt freighter, B9 Shipping's 3000 dwt bulker and Dykstra/ Fair Transport's 7000 dwt Ecoliner are the current application of the soft-sail technology.10 Fuel savings using this technology has been predicted up to 60 % and significant emission reduction.[12]

Fixed-sails are essentially rigid 'wings' on a rotating mast. Various form of modern wing sail concepts was provided by the Japanese researchers and protypes were tested in the early 80's which all were inspiration from the successful installation of rigid sail on an oil tanker JAMDA in 1970.[2] Current proposals include use of rigid sails capable of reefing down on telescoping masts for heavy

[11] https://www.bbc.com/future/article/20201127-how-hydrogen-fuel-could-decarbonise-shipping
[12] https://newatlas.com/b9-shipping-cargo-sailing-ships/23059/

weather or in-port situations. UT Wind Challenger project which is led by ship owner Mitsui O.S.K. Lines, shipyard Oshima Shipbuilding, and University of Tokyo is an example of rigid wing sail in which more than 30% fuel savings have been proposed.[2]

(a) (b)

Fig. 3 (a) B9 cargo ship with soft sail[12] (b) Windship with rigid sail[13]

Flettner Rotors harness the Magnus Effect, created when wind passes over an already revolving cylinder, for propulsion.[10] The technology was first usefully applied the 1920s on a number of ships, including the 3000 dwt Barbara.[10] Today's rotor sail technology has been considered mature and viable areas with adequate wind condition. The technology already has sought the attention of policy makers, academic institutions, shipping and energy companies. Enercon launched the hybrid rotor ship E-Ship 1 on 2nd August 2008. From 2010, it has been used to transport the company's turbine products and other equipment. Enercon claim "operational fuel savings of up to 25% compared to same-sized conventional freight vessels.

Towing kites provide thrust to ships with the lift generated by high altitude winds. From 2008 to 2012, some commercial applications of towing kites were developed by Skysails. Airseas another wind assisted ship technology provider company has also developed towing kite for ship's propulsion. The kites are expected to cut about 20% fuel of ship. [15]

Solar power is another way to reduce fuel consumption on-board ships. Photovoltaic (PV) cells generate the electricity from solar. Limited deployment area for the PV panels and energy storage are major limitation of the use of solar power. Recent advances in solar cell and photovoltaic module technologies have led to solar power becoming a cost-effective fuel reduction option on pleasure boats, ferries and tourist vessels. However, on large ships the amount of fuel saved through the use of solar power alone is relatively small. Solar PV mainly in hybrid models with other energy sources on small ships, such as NYK's Auriga Leader and Solar Sail or by OCIUS Technology (formerly Solar Sailor Holdings Ltd).[10]

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[13] https://mfame.guru/wind-assisted-propulsion-for-fuel-cost-emission-cut/

[14] Enercon (2013). Rotor sail ship "E-Ship 1" saves up to 25% fuel

[15] Chou, T.; Kosmas, V.; Acciaro, M.; Renken, K. A (2021). Comeback of Wind Power in Shipping: An Economic and Operational Review on the Wind-Assisted Ship Propulsion Technology. Sustainability, 2021–13, 1880. https://doi.org/10.3390/ su13041880

(a) (b)

Fig. 4 (a) Enercon ship awith rotor sail[14] (b) Airseas towing kite ship sail[15]

Table 1 Current projects/ technologies on wind assisted ship propulsion[2]

Name of the technology	Expected fuel savings (%)	Projects/Concepts/ Technologies Provider	Current status
Rigid wing sails	10–40	Eco Marine Power Wind ship Technology Wind Ship powered by nature, UK Ocean foil wing sail technology Propełwind, France	Concept, Design, CFD simulation
		MOL wind challenger (Wind Challenger Project)	Detail design and software development for control mechanism.
		NAYAM wings	Model test completed successfully, intending to start construction
Square rig sail systems (Dyna-Rig)	Up to 50	B9 Sail Cargo Ship Dykstra Naval Architects	Concept for new build ship
Towing kites	10–30	Maltese Falcon SkySails Marine	In operation since 2006 One ship in operation
		Beyond the sea	Concept, Design, CFD simulation
Flettner rotors	20–30	M/V Estradenro-ro by NorsepowerOy Ltd E-Ship 1	In operation
	35–50	Magnuss Voss Wind Hybrid Coaster Anemoi Flettner rotors	Construction

Converting wave energy into propulsive thrust to propel a boat was first proposed in 1858 and successfully implemented in 1890.18 A number of experiments in both model and full scale have been carried to demonstrates the feasibility of wave-powered boats. The most common type of

[16] https://www.cargo-partner.com/trendletter/issue-10/sails-and-kites-support-cargo-ships

wave propelled technology is a boat with foils that convert the vertical motion in waves into propulsive thrust. Wave Energy based propulsion innovation is a biomimetic dynamic wing mounted at the bow of the ship to increase propulsion in moderate. Extra thrust is produced by capturing the sea waves and ship motions are dampened. In addition to saving fuel, another benefit of wave foils or wings are that they significantly reduce the most violent vessel motions.[17]

Table 1 shows current state of art of wind assisted propulsion technology. However, some literature and projects suggest that a combine approach of renewable energy technologies (i.e., wind, wave or solar) and alternative fuels (i.e., LNG, LPG, Fuel cell etc.) along with improved hull and propulsors design can be significantly beneficent to make ultimate energy efficient zero emission shipping.

(a) **(b)**

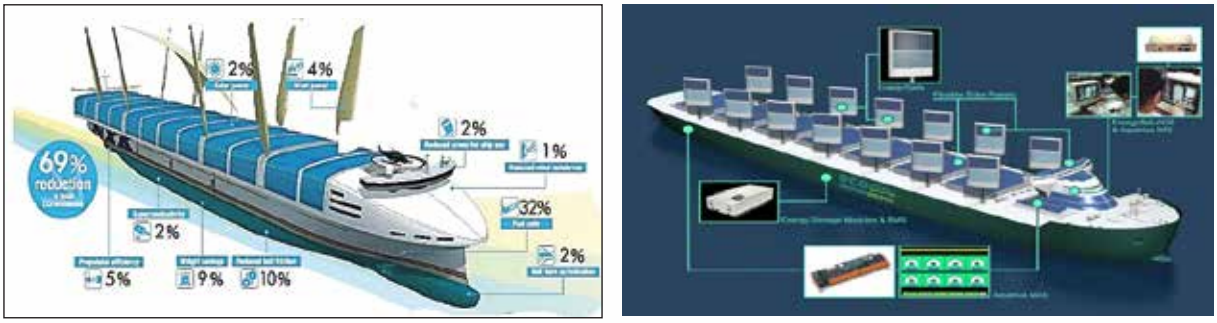

Fig. 5 (a) NYK Super Eco ship 2030[18] (b) Aquarius MRE® [19]

NYK Super Eco 2030, NYK Super Eco 2050 and Aquarius MRE® - Wind & Solar Power for Ships are examples of ultimate green ship technology. The NYK Super Eco 2030 is different from traditional craft in that it uses less energy to propel itself by reducing vessel weight and drag, as well as employing environmental technologies that are thought to be important in the future, such as fuel cell energy conversion, maximum use of renewable energy sources like solar and wind power, and navigational improvements. It is a container vessel of the future in these ways, lowering carbon dioxide emissions by 69%.[19]

Conclusion

The shipping industry must have to look for alternative options for energy efficient ship propulsion to comply the legislation set by IMO. Alternative fuel such as LGN, LPG, Hydrogen fuel cell and biofuel can play a vital role in future shipping. Wind-assisted ship propulsion technology seems to be a promising solution toward the greener shipping industry. A combined approach of alternative fuel along with wind technology may bring more beneficiary for decarburizing and reducing fuel consumption of ships. Only the general aspects of the alternative future powering options for greener ship have been discussed. Moreover, details technical challenges and barrier of the implementation of the technologies must be taken into consideration to draw a precise conclusion regarding use of alternative fuels and renewable energies.

[17] Eirik Bockmann (February 2015) Wave propulsion of ships. PhD Thesis, Norwegian University of Science and Technology, Norway.

[18] https://www.designboom.com/design/nyk-super-eco-ship-2030/

[19] https://www.ecomarinepower.com/en/wind-and-solar-power-for-ships

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Distance Learning: A Novel Way Forward for Education

Tasmia Hoque

The 21st century was full of technological and cultural revolutions which speeded up our civilization by several years. This also revolutionized education by its numerous efforts for making it universally accessible through the idea of distance learning. By definition, distance learning can be described as mode of education that is received at another geographical location for students who may not always be physically present at a school . Nowadays it is also commonly known as online education. As a concept it is not entirely new. The whole idea started in 1840 by Sir Isaac Pittman for teaching shorthand course by mailing students in postcards and even receiving feedback mails from them . Later many colleges and universities adopted this technique modifying it into a correspondence course. Founded in 1894, Wolsey Hall, Oxford in UK was the first distance learning college .

Although the initial method of distance learning was these correspondence courses, with the revolution of technology many other forms followed such as radio, television and the internet. The first large-scale implementation of radio for distance education took place in 1937 in Chicago during a three weeks school closure due to polio outbreak . After the invention of television distance learning became much easier and commonplace as it could provide both audio visual learning capabilities. Then came the internet and made these earlier distinct forms somewhat redundant as internet empower learners with the capacity of using voice, video, text and immersive teaching methods altogether in the same platform. Internet provides many forms of distance learning through open educational resources and facilities such as e-learning and MOOCs . Although it is hard to put boundaries among them, distance education technologies can be divided into two modes of delivery: synchronous learning and asynchronous learning. While in synchronous learning, all participants are to be "present" at the same time in a virtual classroom; asynchronous learning enables students to access course materials on their own schedule. Web conferencing, live streaming, video conferencing, educational television, instructional television shows are examples of synchronous technology. Asynchronous learning includes email, audio and video recordings, print materials etc. The methods can be combined which is called Hybrid or Blended learning. Here students are required to be available at fixed time in the Internet chat room or classroom but are allowed to complete assignments at their own pace and later submit them online .

Worldwide a number of universities are offering distance education courses from the most basic instruction through to the highest levels of degree and doctoral programs. Also E-Courses are available

[1] https://en.wikipedia.org/wiki/Distance_education#cite_note-Kaplan_Haenlein_2016-1
[2] https://en.wikipedia.org/wiki/Distance_education#cite_note-6
[3] https://www.washingtonpost.com/education/2020/04/03/chicago-schools-closed-during-1937-polio-epidemic-kids-learned-home-over-radio/
[4] https://www.sciencedirect.com/science/article/abs/pii/S000768131630009X
[5] https://en.wikipedia.org/wiki/Distance_education#cite_note-lever-Duffy-45

from websites such as Khan Academy, Udemy, Coursera, MasterClass etc. on many topics. In Bangladesh, the first ever distance learning was introduced through the establishment of Bangladesh Institute of Distance Education (BIDE) in 1983. For its massive success, Govt. Passed the Bangladesh open university (BOU) act in 1992.Today BOU offers a total of 21 formal and 19 non formal academic programs [6].

Distance learning is beneficial for students, teachers and institutions on a multidimensional level. It expands access to education and training for both general populace and businesses for its flexible scheduling structure. Within the class, students are able to learn in ways that traditional classrooms would not be able to provide. They can review their lessons more than once according to their needs and then manipulate the coursework to fit their learning by focusing more on their weaker topics. The improvement in communication amongst students and their classmates has provided them with as many opportunities as they would get in in-person education. By accessing various global institutions and being introduced to broad array of thoughts from across the globe, students can build their own thoughts and opinions. Distance education has been a more cost-effective form of learning and can sometimes save students and also the institutions a significant amount of money as opposed to traditional education. The availability of some textbooks as electronic books has led to many university libraries making partnership with many digital publishers that offer course materials for free. It also enables students with 'disability' or from disadvantageous geographical places to pursue their dream of higher education.

It will remain incomplete if we don't mention the contribution of distance education in the COVID-19 pandemic situation in helping the educational institutions maintain their scheduled courses. The pandemic greatly interrupted education worldwide, but thanks to online education, the schools, colleges and universities are continuing their classes and exams through many online learning platforms including Zoom, Cisco WebEx, Google Classroom, Google Meet, Microsoft Teams, D2L etc. In Bangladesh, many institutions also chose these platforms to conduct online class and even exams during this pandemic. Moreover, UNICEF has published a guidance on distance learning modalities to reach all children and youth during school closure. It has been focusing on low and no tech modalities to reach to the most marginalized.

Certain drawbacks of online education had always been present but the pandemic brought many of these under the broad daylight demanding appropriate attention to resolve them. Some students attempt to participate in distance education without proper training with the tools needed to be successful in the program. Students must be provided with training opportunities (if needed) on each tool that is used throughout the program. Also, time management skills and self-discipline in distance education is just as important as complete knowledge of the tools being used for learning. The results of a study of Washington state community college students showed that distance learning students tended to drop out more often than their traditional counterparts due to difficulties in language, time management, and study skills [7]. Not only students but teachers and instructors are also facing difficulties due to lack of experience in using these technologies. In developing and under-developed countries, the slow speed of internet and mobile networks are

[6] https://bou.ac.bd/

[7] https://ccrc.tc.columbia.edu/publications/online-hybrid-courses-washington.html?UID=872

also posing difficulties in the smooth running of online classes. Not all courses required to complete a degree may be offered online. Health care profession programs, in particular, require some sort of patient interaction through fieldwork. A more complex challenge of distance education relates to cultural differences between students and teachers and among students. However, the key to bridge this gap demands a proper understanding and awareness of the norms, differences, preconceptions, and potential conflicting issues.

The vast arrays of scopes and merits that this mode of education provides far outweigh the relative shortcomings. Never before the thought crossed our mind that our traditional medium of education would be so severely challenged by any mean such as this gruesome pandemic, only then we've realized the true necessity of such a wonderful alternative medium of learning. Distance learning should no longer be treated as an alternative but coexist with face-to-face learning programs. Steps have to be taken to furnish this learning mode with necessary modifications to make it best suited for all the purposes that it can serve to ensure best quality education for students across the globe.

Author's Brief Biography

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Worldwide Shipbuilding Trend: Impact of Covid Pandemic & Future Prospect

Kazi Rafi Rahaman

Shipbuilding is known as one of the oldest, most open and highly competitive markets in the world. Although shipbuilding industry has a big experience in how to survive over peaks and slumps of economy, the current global crisis hit shipbuilding industry rather severely. The need to import and export goods, as sparked by globalization, made shipbuilding an important strategic industry. Although Europe remains a crucial market for the production of cruise vessels, the East Asian region dominates shipbuilding with China, Japan, and South Korea being the largest shipbuilding nations in the world. China alone received some 48 percent of all shipbuilding orders in 2020, making it a global shipbuilding powerhouse.

Historically, shipbuilding industry has suffered from the absence of global control and role and there is a tendency towards over-investment due to the fact that shipyards offer a wide range of technologies, employ a significant number of workers and generate income as a shipbuilding market. On the other hand, it is very common that shipbuilding is always a state supported industry and enjoy government subsidies[1].

Until the middle of the last century, European shipbuilding dominated the world. Fast growth of the Japanese economy and successful coordination of supporting program for shipbuilding as a strategic industry helped to win leadership for this country. For some time, Japan and Europe controlled 90% of the market, but gradually dominance was overtaken by China and Japan. China, caught the industrial expansion strategy and surpassed Japan in 2006 and S. Korea in 2009 (if measured by order book volumes). New shipbuilding entrants such as Vietnam, India, Turkey, the Philippines, Brazil, and Russia grew up and together reached the quantity of orders to equal European total[2]. Europe has gradually been losing its positions in shipbuilding despite of its strategic specialization as a niche player. Unfair competition on the part of Asian shipyards and delayed agreements in global playing field have distorted the market, shifted it to the Far East and created extra problems fighting against crisis. After East Asian countries became the dominant players in the cargo shipbuilding industry in the late 20th century, knowing they could not compete with the East Asian competition, European shipyards started specializing in the production of passenger vessels. Up until the COVID-19 pandemic broke out in early 2019, this strategy was paying off. While Asian shipyards were suffering from insufficient demand and overcapacity of shipyards, European ship builders were thriving. The COVID-19 pandemic, however, disrupted this status quo. With passenger travel coming to a standstill, especially in the cruise industry, the demand for new passenger vessels at European shipyards plummeted. East Asian ship producers, on the other hand, are having trouble meeting the rising demand for cargo ships[3].

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[1] Lixing Zou, 2009. Development oriented finance and economy in China: A historical review and prognostic assessment. Printed in Bloomington, Indiana, USA, 2009.

[2] Michael Dillon, 2010. China: A modern history, I B Tauris and Co Ltd, London, UK, 2010.

[3] Shipbuilding industry worldwide - statistics & facts; Published by Statista Research Department, Aug 30, 2021

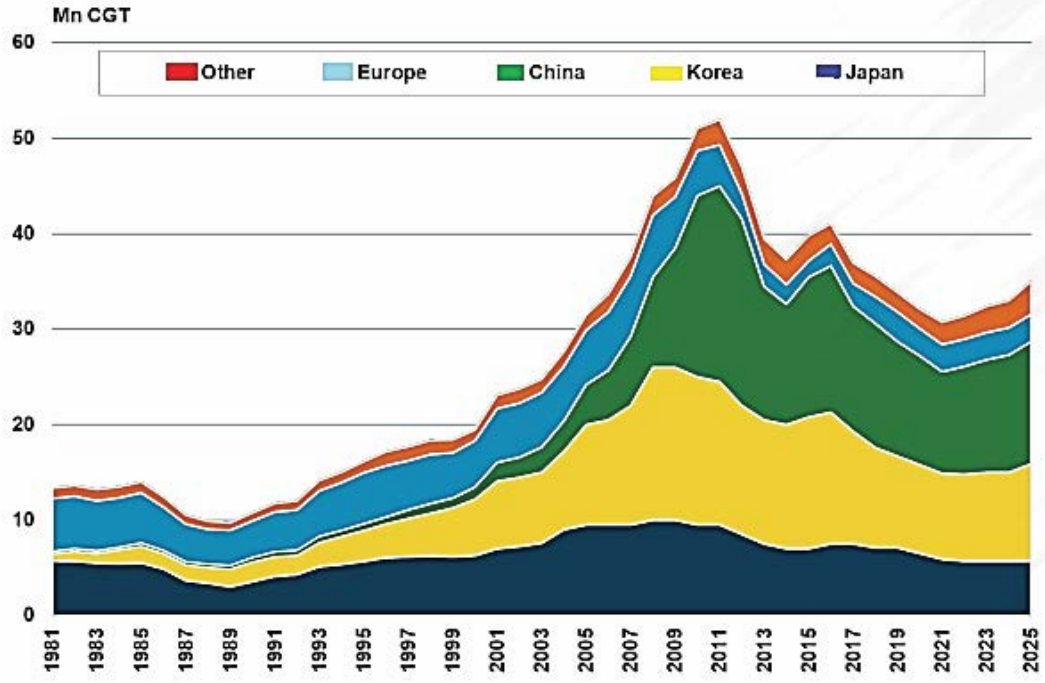

Figure: Worldwide shipyard capacity evolution[4]

China is an emerging shipbuilder that overtook South Korea during the time of global financial crisis in year 2008 to 2010. China is the largest shipbuilder in the world. According to the Ministry of Industry and Information Technology (MIIT) of China, the country had a share of 43.1%, 48.8%, and 44.7% of the global market, in terms of delivery orders and order book. At present, Korea is the world's second largest shipbuilding country with a global market share of about 29% in. South Korea leads in the production of large vessels such as Super tanker, cruise liner, LNG and LPG Carrier, drill ship, offshore structure (FSPO, FPO) and large container ship. South Korea's shipyards are highly efficient. While evaluating the trend of global shipbuilding industry, it is found that, Japan had been the dominant ship building country from the 1960s through to the end of 1990s but gradually lost its competitive advantage to the emerging industry in South Korea which had the advantages of much cheaper wages, strong government backing and a cheaper currency. South Korean production overtook Japan's in 2003 and Japanese market share has since fallen sharply.[3] Philippines has placed fourth among shipbuilding nations around the world producing more than six million deadweight tons of ships built in 2012[5].

Market Overview

The global shipbuilding new orders reached 42.74 million GT in 2019. The factors such as increasing sea-borne trade, accelerating economic growth, growing energy consumption and rising demand for eco-friendly ships are expected to drive the market. However, growth of the industry

[4] https://www.oecd.org/industry/ind/WP6-Workshop_Item_3.1_Kent.pdf

[5] Philippines: fourth largest shipbuilding nation in the world;
http://www.dk-export.dk/nyt-og-presse/nyheder/$5-billion-maritime-business-inthe-philippines

would be challenged by the environmental regulations, risk of cyber breaches and trade wars. A few notable trends include average age of world merchant fleet, significant steel usage, Korean government taking initiatives to support the shipbuilding industry, major companies restructuring Japanese shipbuilding industry and growing demand for LNG bunkering[6].

The shipbuilding industry is responsible for the design and construction of ocean-going vessels. Most of the global ship production today is concentrated in Asian countries such as China, Japan and South Korea, though large shipyards also exist in many other countries. The shipbuilding industry is involved in the construction and modification of ships and these operations are carried out in specialized facilities called shipyards. The shipbuilding industry primarily supplies the shipping industry and, hence, a shipbuilding cycle cannot be discussed entirely outside the context of a shipping cycle. Basically, the supply-demand gaps in the shipping industry leads to shipbuilding cycles. Increasing demand for shipping services and energy consumption in developing economies supported the demands for bulkers and tankers, globally.

The Ship Building market was valued at USD 126 billion in 2020 and is anticipated to reach USD 167 billion by 2026, at a CAGR of more than 4%, during the forecast period (2021 – 2026). The outbreak of COVID-19 has affected the shipbuilding sector in several countries. The negative impacts of the pandemic were seen in the global ship supply chains. Considering the longer timelines involved in the development of sips, the delays are expected to result in extra expenditures for the shipbuilders. For instance, in Canada, the construction of new naval ships by Irving and Seaspan ULC in Vancouver has been delayed due to supply chain disruptions due to lockdowns and the COVID-19 measures at their shipyards. Hence, the reduction in production rates due to the pandemic-induced disruptions is expected to hinder the growth of the market during the initial few years of the forecast period[7].

However global shipbuilding market is expected to grow in the future due to increasing seaborne trade and economic growth, rising energy consumption, the demand for eco-friendly ships and shipping services, and the advent of robotics in shipbuilding.

Shipbuilding is considered to be one of the oldest, most open and highly competitive markets in the world. Although shipbuilding industry has vast experiences in surviving peaks and slumps of economy, the current global crisis has hit shipbuilding industry more severely. Strong government support and political stability is required in this industry because of being highly capital intensive. There is still huge room for shipbuilding industry to grow in the next decade. However, the expansion of shipbuilding industry may be affected by increased competition, environmental regulations, enhanced globalization and political and financial instability. Shifts in global demographics and population growth rates, coupled with long-term economic growth in developing markets, will have implications for the maritime sector over the course of the next decade.

[6] Dublin, April 21, 2020 (GLOBE NEWSWIRE) -- The "Global Shipbuilding Market Report with Potential Impact of COVID-19: 2020 Edition"

[7] Dublin, June 08, 2021 (GLOBE NEWSWIRE) -- The "Ship Building Global Market Report 2021: COVID-19 Impact and Recovery to 2030"

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Higher Studies to Produce Safer Naval Architects

Kaniza Islam

Over the past century, naval technology has developed leaps and bounds. Ships and other sea-going vessels, along with the technologies of marine navigation and shipbuilding, have seen huge advancements, leading to the establishment of various dedicated fields of study. Naval architecture is one such specialized field, which is an integral part of the shipping industry. Naval architecture is the name given to the science and engineering of designing and manufacturing sea-going vessels such as ships, yachts, powerboats, steamers, tugs, fishing boats, barges, warships, cruise ships, icebreakers, and even submarines. In addition to these, the study of naval architecture deals with the design and manufacturing of offshore structures of all kinds, whether commercial or military. [1, 2]

More than 70% of our planet is covered by water. The earth's oceans, rivers, lakes, and coastal margins are all part of the marine environment. In the department of Naval Architecture & Marine Engineering (NAME), the study of designing and manufacturing sea-going vessels is carried out.[3] The innovative NAME concentration is created to fulfill local demands; the innovative NAME concentration prepares students for engineering-related careers in shipbuilding or offshore industries. Many NAME graduates have become naval architects or marine engineers who work across a variety of fields.[4] The department has the vision to establish itself as a center of excellence in naval architecture and marine engineering program for producing well-qualified graduate engineers capable of meeting the challenging and ever-expanding needs of sustainable development and management of world-class shipbuilding.[5, 6]

The marine industry needs engineers with advanced degrees and offers them high-paying career opportunities. Thousands of men and women are employed in the marine industry, and many of them are naval architects and marine engineers who work on:

- The design of ships, boats, and offshore structures
- The marine systems for shipping raw materials and finished products
- The frontiers of deep-sea exploration and mineral recovery
- The operation and servicing of marine systems.[7]

Procedure to Become a Naval Architect

The procedure of becoming a naval architect depends on the country one belongs to. One should find information about their respective country by going through the website of some prominent maritime academies.

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[1] www.marineinsight.com
[2] www.britannica.com
[3] http://websites.umich.edu/~nameweb/Grad_Brochure.pdf
[4] https://www.uno.edu/academics/coe/engineering-ms
[5] https://name.buet.ac.bd/vision-and-mission
[6] https://mist.ac.bd/department/name
[7] https://www.uno.edu/academics/coe/name/graduate

Further Studies can a Naval architect do

A naval architect can pursue a range of specializations offered by various universities. Some are ship design, structural design, marine structures, hydrodynamic design, and offshore structures design. The range of specializations and course offerings vary according to the universities offering them.

Famous Naval Architecture Colleges in abroad

In India, the universities offering the best naval architecture courses of the country are:

- Indian Maritime University, Visakhapatnam Campus
- Indian Institute of Technology, Kharagpur
- Indian Institute of Technology, Madras
- AMET University, Chennai

Some of the universities that are globally known for their naval architecture courses are:

- Osaka University- Japan
- The University of New Orleans- USA
- University of Southampton- UK
- University of Strathclyde- UK
- University of Michigan- USA
- University of Genoa, Italy
- KTH Royal Institute of Technology, Sweden
- University of British Columbia, Canada
- Harbin Engineering University, China
- University of New South Wales, Australia
- Singapore Institute of Technology, Singapore.

A master's degree generally follows after completion of an undergraduate science degree. Requiring three to four years to complete, master's degree programs typically consist of a mix of course work and research projects.[8]

Individuals considering an advanced degree in engineering or ship design may ask, "What is a Master in Naval Architecture?" Generally consisting of advanced studies in the science of ship design, including modeling and testing, and a thorough understanding of related principles such as fluid dynamics, a master's degree in naval architecture prepares students for success in maritime industry positions. The benefits of taking a Master in Naval Architecture include advanced competency in skills and knowledge related to sea vessels and structures. Some students pursue a master's degree in naval architecture in preparation for doctorate studies in a related field.[9]

An Erasmus Mundus Joint Master Degree (EMJMD) is a prestigious, integrated, international study program jointly delivered by an international consortium of higher education institutions.

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[8] www.masterstudies.com

[9] https://www.hotcoursesabroad.com/study/training-degrees/international/naval-architecture-courses/cgory/xq.2-4/sin/ct/programs.html

Students at the Master's level from all over the world can apply.[10] The objective of the EMSHIP education platform is to provide a high education level in Naval Architecture and Ship & Offshore Design. EMSHIP leads to a Double Master degree in Offshore Structures and Marine Engineering and Ship Design from one of these 3 institutions:

- Ecole Centrale de Nantes (ECN, Fr) Ship & Marine Hydrodynamics
- Rostock (URO, Germany) Ship Technology & Ocean Engineering
- Szczecin (ZUT, Poland) Advanced Ship & Offshore Structures[11].

According to DATA USA, Massachusetts Maritime Academy awards the most degrees in Naval Architecture & Marine Engineering in the US. Institutions with the most degrees awarded in naval architecture & marine engineering

- Massachusetts Maritime Academy
- Maine Maritime Academy
- United States Merchant Marine Academy

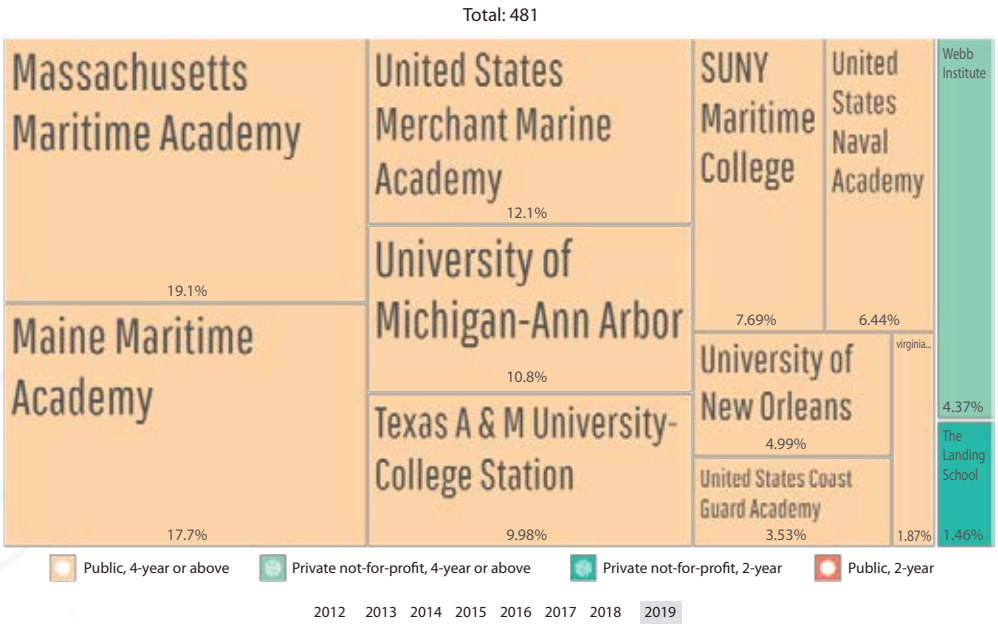


Figure- Statistics of Naval Graduates in USA (2019).

A relatively high number of people born in India hold Engineering degrees (4.35 times more than expected), and the most common country of origin by total numbers for non-US students earning a degree in this field is India (466,852-degree recipients).

Most common countries of origin-

- India, 466,852-degree recipients
- China, 156,358-degree recipients
- Mexico, 85,234-degree recipients

High relative number of students-

[10] https://ec.europa.eu/programmes/erasmus-plus/about/statistics_en

[11] https://www.marj3.com/en/get-your-masters-in-advanced-ship-and-offshore-design-from-erasmus-mundus-2020.html

- India- 4.35 times more than expected
- Iceland- 4.24 times more than expected
- Libya- 4.16 times more than expected[12]

Learning Outcomes of Naval Architects

The course prepares students for careers in one of three areas:
Marine and Offshore Engineering - Building on core fundamental engineering units, this degree specializes in mechanical and mechanical-electrical power generation, machinery, and operational systems.

Naval Architecture - the shipbuilding industry, high-speed ferry industry, marine consultancy firms, and government in commercial shipping, transport policy and administration, and the insurance sector.

Ocean Engineering - the design, construction, installation and management of offshore fixed, floating, subsea and coastal structures. The degree integrates a core set of fundamental engineering units which focus on wave mechanics, hydrodynamics, structural mechanics, and dynamics of offshore and subsea structures and coastal technologies.[13]

Advance one's engineering career with the technical skills to work in naval-related sectors; this specialization builds on the existing skillset to improve the design and performance of naval vessels. One will graduate with an understanding of maritime engineering systems and the technical design abilities required to undertake naval projects.[14]

Shipping has continued to transport more than 80% of world trade, including vital medical supplies, food, and other essential goods that are critical for the COVID-19 response and recovery. Shipping is the most efficient and cost-effective method of international transportation for most goods; it provides a dependable, low-cost means of transporting goods globally, facilitating commerce and helping to create prosperity among nations and peoples. The world relies on a safe, secure, and efficient international shipping industry, which is an essential component of any program for future sustainable green economic growth in a sustainable manner. So energy efficiency, new technology and innovation, maritime education and training, maritime security, maritime traffic management, and the development of the maritime infrastructure, the development and implementation of global standards covering these and other issues will underpin IMO's commitment to providing the institutional framework necessary for a green and sustainable global maritime transportation system. Therefore, it goes without saying that the importance of higher education is immense to produce Safer Naval Architects.

[12]https://datausa.io/profile/cip/naval-architecture-marine-engineering?__cf_chl_captcha_tk__=pmd_WirIG2YC1R_TU6jeE_gNdYdasKBcpC7dg50QzDNWS94-1630306988-0-gqNtZGzNAvujcnBszQiR#about
[13]https://students.flinders.edu.au/my-course/course-rules/undergrad/bengnah
[14]https://www.utas.edu.au/courses/cse/courses/j7z1-master-of-maritime-engineering-naval-engineering

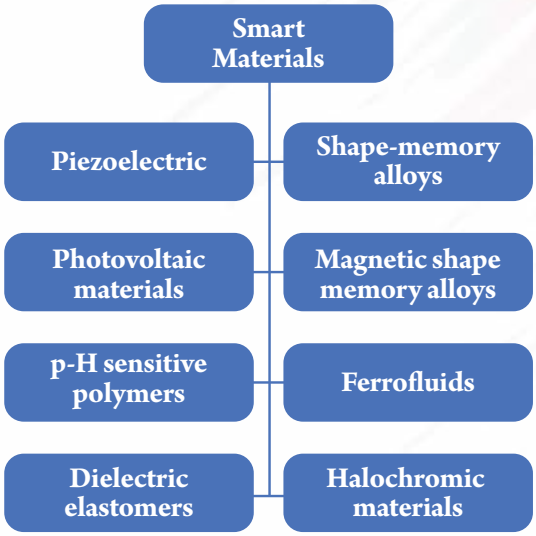
Author's Brief Biography

Kaniza Islam has been a Lecturer in the department of Naval Architecture and Engineering at the Military Institute of Science and Technology (MIST) since 2019. She obtained her bachelor's degree in Naval Architecture and Marine Engineering from MIST with distinct results in 2018. For outstanding academic results, she received Commandant's Recommendation from MIST. Kaniza attended industrial training for 30 days in Western Marine Shipyard Ltd, Chittagong Dry Dock Limited (CDDL), and Commodore Superintendent Dockyard - Bangladesh Navy in 2017. She enjoys using her skills to contribute to the teaching of the students every day at MIST. Her devotion is to achieve her perennial dream to become a successful scholar and an engineer. Kaniza currently resides in Dhaka and she enjoys baking, travelling and meeting new friends.

Smart Materials for Safer Shipbuilding

A S M Araf Raihan

Smart materials, also called intelligent or responsive materials, are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, moisture, electric or magnetic fields, light, temperature, pH, or chemical compounds.[1] Terms used to describe smart materials include Shape Memory Material (SMM) and Shape Memory Technology (SMT).[2] Smart materials can be employed in shipbuilding industry which promises intelligent vibration damping, better thermal regulation and shape-changing hulls for improved hydrodynamics.[3] The installation of these smart materials will also help in minimizing operational costs, passenger comfort and reduced carbon emissions.



Promising results have been found by applying smart materials in shipbuilding. These include: the use of Photovoltaic (PV) systems to restrict the uses of greenhouse gases[4], research on piezoelectric energy as a way to promote renewable energy[5], efficient design procedures by employing magnetic fluid seals intended for operating in gas environment or vacuum[6], use of composite materials to promote cost benefit aspects[7] and use of SMA (Shape Memory Alloys) in tube connectors, thermostat and continuous loop spring in subsea power plant.[8] World Maritime Organization has ruled out to reduce pollutant emissions by 25-30% by 2030[9] and for that, the use of smart materials is an effective way to do this. Smart materials can work as renewable energy as they can used repeatedly. If the case of greenhouse gases is considered, maritime transport is responsible for more than 3% of global CO_2 emissions and the total emissions from this sector continue to increase to 5% by the year 2050[10]. Use of smart materials will also offer passenger comfort and durability of materials used in shipbuilding.

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[1]https://www.imo.org/en/About/Events/Pages/World-Maritime-Theme-2021.aspx

[2]https://en.wikipedia.org/wiki/Smart_material

[3]https://cordis.europa.eu/article/id/165981-adaptive-and-smart-materials-and-structures-for-ships

[4]I. Kobougias, E. Tatakis, J. Prousalidis (2013) PV Systems Installed in Marine Vessels: Technologies and Specifications, Hindawi

[5] H. Han, J. Ko (2021) Power-Generation Optimization Based on Peizoelectric Ceramic Deformation for Energy Harvesting Application with Renewable Energy, MDPI

[6] L. Matuszewski, Z. Szydlo (2011) Life tests of a rotary single-stage magnetic-fluid seal for shipbuilding applications, Polish Maritime Research

[7] P. Noury, B. Hayman, D. McGeorge, J. Weitzenbock (2002) Lightweight construction for advanced shipbuilding-recent development, Researchgate

[8] S. Ivosevic, R. Rudolf (2019) Materials with Shape Memory Effect for Applications in Maritime, sciendo

[9],[10]10 F. Ulhoa, P. Junior, R. Floriano, V. Coutinho (2017) Electric Power Generation with Peizoelectricity for Cargo Ships, Twelfth International Conference on Ecological Vehicles and Renewable Energies (EVER)

Author's Brief Biography

A S M Araf Raihan has been graduated from the department of Naval Architecture and Marine Engineering, MIST on 27 January, 2020. He is currently pursuing his M.Sc. in NAME in Department of Naval Architecture and Marine Engineering, MIST. He is also working as an adjunct Lecturer in the same department since 19 August, 2020. His research interest lies in the areas of Seakeeping, Materials Science, Computational Fluid Dynamics (CFD) etc.

SHIP DESIGN COMPETITION

3-D Ship Design Competition

Dr. S M Ikhtiar Mahmud

The Naval Architecture and Marine Engineering (NAME) Department at Military Institute of Science and Technology (MIST) organized a 3-D Ship Design competition on the occasion of World Maritime Day 2021 for students all over the world to promote Naval Architecture and the Shipbuilding Industry in Bangladesh. The competition engaged students' creativity and introduced them to engineering, design, drawing and project planning. Participating students had the option to work independently or in small groups to design a ship. The designs were evaluated by the panel of judges for thorough documentation, decisions, proper drawing and calculation accuracy. This competition mainly emphasized and promoted the significance of design in marine sector by bringing together young dynamic designers interested in this sector and contributing to education via creative learning.

Initially, ship design was a process of evolution where the starting point for a new design was a similar existing ship design to which modifications were made as per requirement. The advent of modern analysis tools, software and powerful computers gave students the opportunity for innovation. Ships are complex and their design must be approached in a methodical manner. The absence of basis ship or prototype allowed the students to be innovative and showcase their creativity. This innovative thinking leads to the capability of a ship to float, move and trade. A solid understanding of the relationships between equipment and systems, is vital for effective functionality.

The title of this competition was 3-D Ship Design Competition. The Ship Design Competition was arranged to develop ship design skills in students from various universities and institutions over the world. The design criteria were set as follows:

- Length of the ship shall be between 24m to 200m.
- Any hull shape shall be acceptable as long as it does not violate the design parameters.
- Ships shall be able to adequately and reliably accommodate and secure the steering assembly and propulsion equipment.
- Ships shall be able to carry the arranged payload and remain within these design parameters.
- Ships shall be unique and must not be copies of past submittals.
- Calculations shall be made as per maritime rules, regulations and guidelines.
- Final design package shall be submitted before end-of-day on date specified.

Assessments of the ship's characteristics such as stability, structural integrity, powering, maneuverability and motions were the main targets of the competition. The design must also be cost-effective, environment friendly and require minimum manning. The safety of the ship, the people on board and the environment in which it sails are all important. Ship design is iterative in nature so students should know how to follow the design spiral and understand the effect of this spiral during project planning. Inferences to be drawn from the illustrations are those among the interlocking constraints which must be satisfied.

The overall design, feasibility and efficiency served as the three main factors for evaluation of designs. According to the judges the competition was extremely challenging and all the designs were of the highest quality submitted for a student competition. The awardees were invited to present their designs on the occasion of World Maritime Day on September 30th, 2021 at MIST.

Winners were selected by a panel of judges evaluating the following criteria:

- Principal characteristics
- Concept selection/initial definition and sizing/Parameters ratio
- Hull form development
- General arrangements
- Forward and Aft part of the vessel (Tank, BHD)
- Capacity (Cargo, passenger etc.)
- Outfitting items
- Completeness
- Text and graphics (figures)
- Overall Quality and Originality

There were 125 designs, where 93 designs are from MIST, 12 from BUET, 8 from Bangabandhu Sheikh Mujibur Rahman Maritime University and 5 from Sonargaon University, 05 from Universiti Teknologi Malaysia (UTM) and 02 from USA were received for the competition amidst this pandemic. All the participants displayed good design skills and professionalism. Amongst them 10 (ten) were selected as finalists and received remuneration and prizes for their excellent submissions. The winners were from Universiti Teknologi Malaysia (UTM), Military Institute of Science and Technology (MIST), Bangladesh University of Engineering and Technology (BUET), Bangabandhu Sheikh Mujibur Rahman Maritime University (BSMRMU) and Sonargaon University (SU).

Nurin's team was distinguished for performing an excellent study in response to the fulfillment of inland requirement criteria of passengers arrangement and design.

Ships design is an amalgamation of art, technology, innovation and environment. It is a process that brings together a wide range of disciplines and analysis procedures. The objectives of this 3-D Ship Design Competition for the students were to create awareness about the significance of ship design on the eve of World Maritime Day 2021, to incorporate all the latest technologies concerning navigation, propulsion, and cargo handling equipment and to optimize ship speed with maximum bearable cargo weight. The competition was successfully completed with tremendous support from all the stakeholders and fulfilled the requirements set up by the Department.

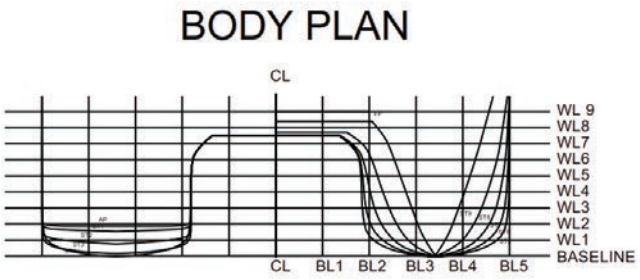
The following participants have been declared as winners by the panel of judges.

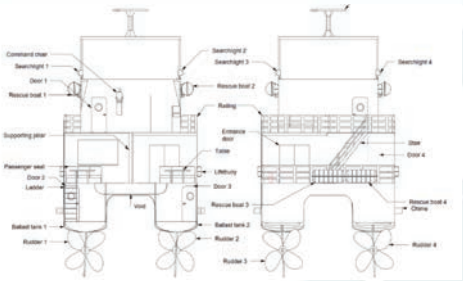
Position	Name of the Participant	University/ Institute	Type of Ship	Prizes
1st	Nurin Athirah Binti Noor Suryadi, Muhammad Azrul Rashid Bin Zulkifli, Muhammad Faeiz Bin Mohamad and Abdul Azim Bin Abdul Muttalib	UTM	Passenger (Catamaran)	Crest, Certificate
2nd	Md. Hasan Ruhan Rabbi and Md. Mahmudul Hasan Akib	MIST	Landing Platform Dock (LPD)	Crest, Certificate
3rd	MahNahid Hasan, Md. Yasin Arafat and Toufiq Ahmed Sohan	MIST	Oil Tanker	Crest, Certificate
4th	Iren Naher and Ridoy Karmoker Rudro	MIST	100 TEUs Container	Crest, Certificate
5th	Sikder Ariyan Zaman	MIST	Oil Tanker	Crest, Certificate
6th	Shah Md. Newaz Sharif Ahad	MIST	War Ship (Corvette)	Crest, Certificate
7th	Loknath Burman and Md. Sabbir Ahmed	MIST	Bulk Carrier	Crest, Certificate
8th	Mijanur Rahman	SU	Tugboat	Crest, Certificate
9th	Tausif Razzak	MIST	1704 TEUs Container	Crest, Certificate
10th	MD. Rabbi Raihan Imon	BSMRMU	2004 TEUs Container	Crest, Certificate

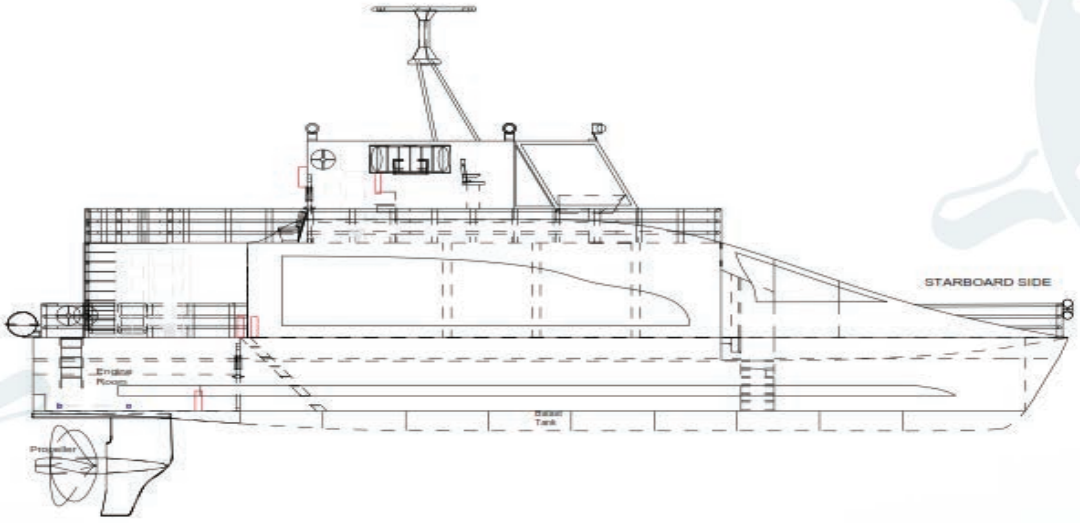
Figure: Poster of 3-D Ship Design Competition

The Department of Naval Architecture and Marine Engineering at Military Institute of Science and Technology has continually strived to promote ship design in Bangladesh since its inception. The 3D Ship Design Competition organized for students all over the world on the occasion of World Maritime Day 2021 is an endeavor for insinuating enthusiasm for ship design and maritime technologies amongst future leaders of the field. After careful evaluation of 125 designs, the expert panel of judges selected the top ten designs which received accolades. The Department will continue to host such activities in the future to bring harmony and unity amongst the maritime industry members of Bangladesh as well as all over the world.

Passenger Catamaran







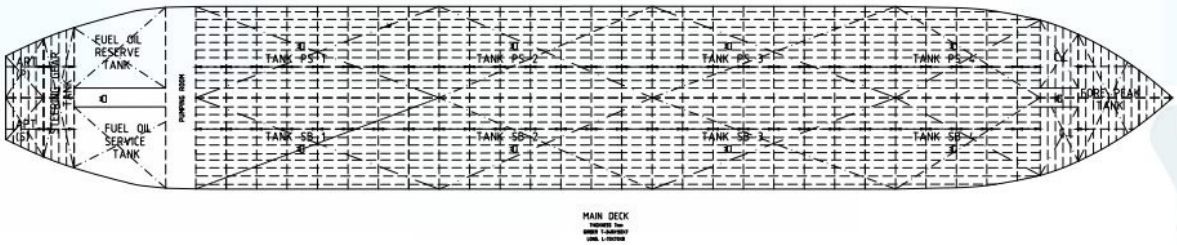
Principal Particulars:

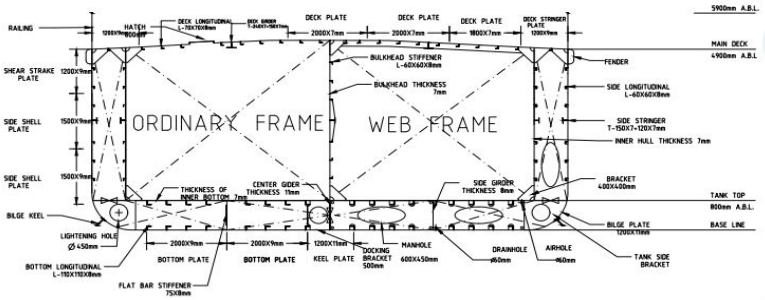
LOA	=	25.00 m
Breadth, B	=	8.00 m
Draft, T	=	1.18 m
Speed	=	31.5 knots

Designed by:

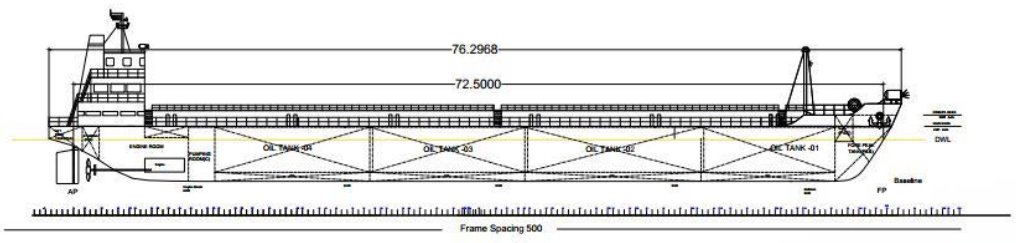
- Nurin Athirah Binti Noor Suryadi
- Muhammad Azrul Rashid Bin Zulkifli
- Muhammad Faeiz Bin Mohamad
- Abdul Azim Bin Abdul Muttalib
- Organization: Universiti Teknologi Malaysia (UTM)

Oil Tanker





ORDINARY FRAME 86 WEB FRAME 88



ELEVATION

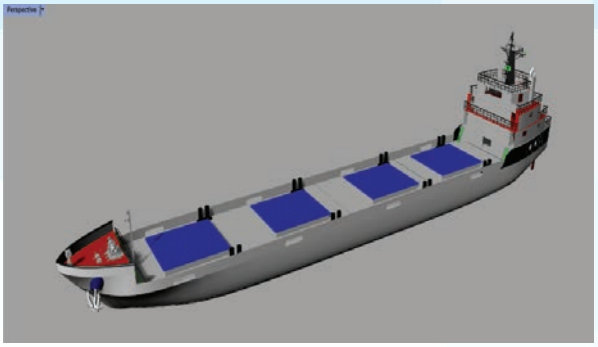
Principal Particulars:

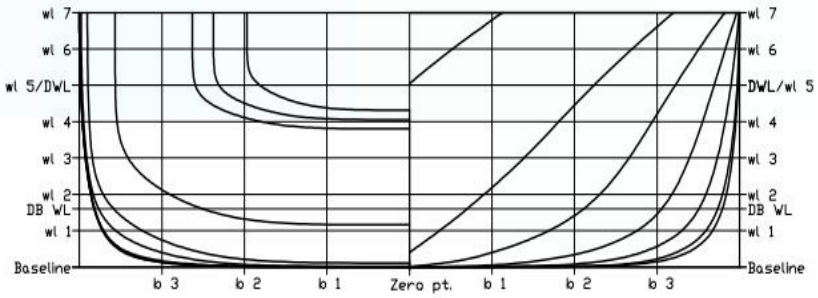
LBP	=	72.5 m
Breadth, B	=	12 m
Draft, T	=	3.7 m
C_b	=	0.806
Displacement	=	2594.5 tons

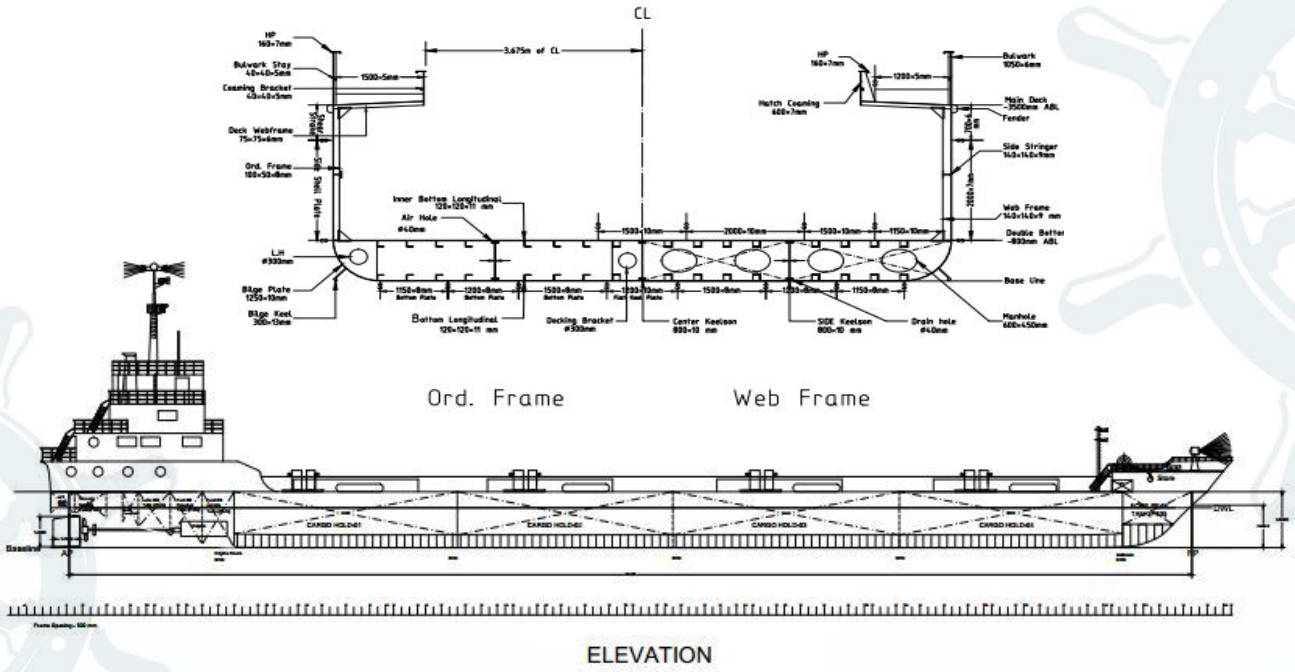
Designed by:

- Nahid Hasan
- Md. Yasin Arafat
- Toufiq Ahmed Sohan
- Organization: **MIST**

General Cargo Ship

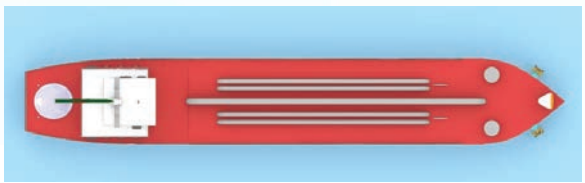


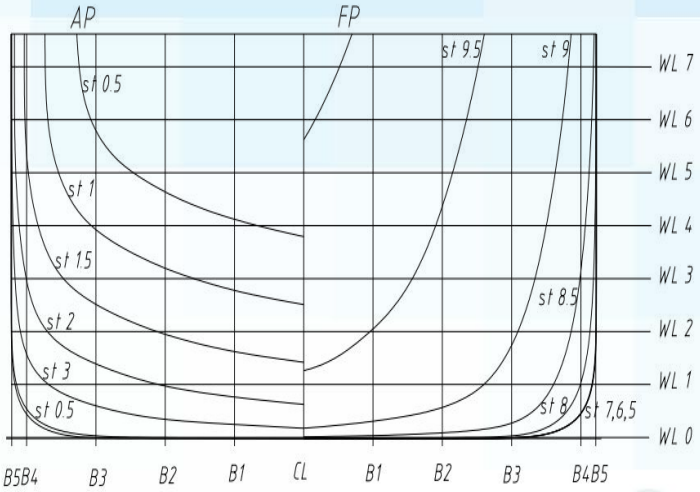


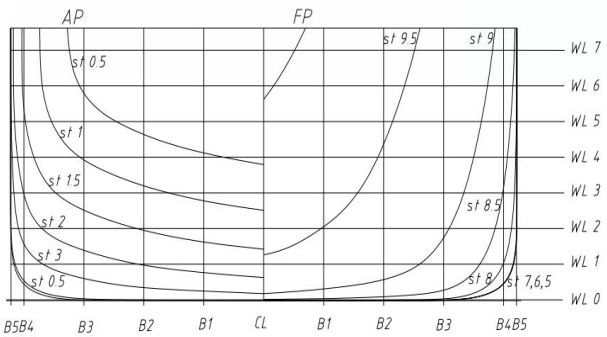


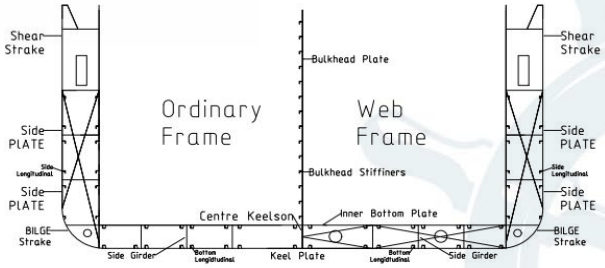
Principal Particulars:			***Designed by:***
LBP	=	69 m	❖ Fatema Akter
Breadth, B	=	10.5 m	❖ Umme Tasnim Sarah
Draft, T	=	2.5 m	❖ Organization: **MIST**
C_b	=	0.78	
Speed	=	14 knots	
Displacement	=	1413 tons	

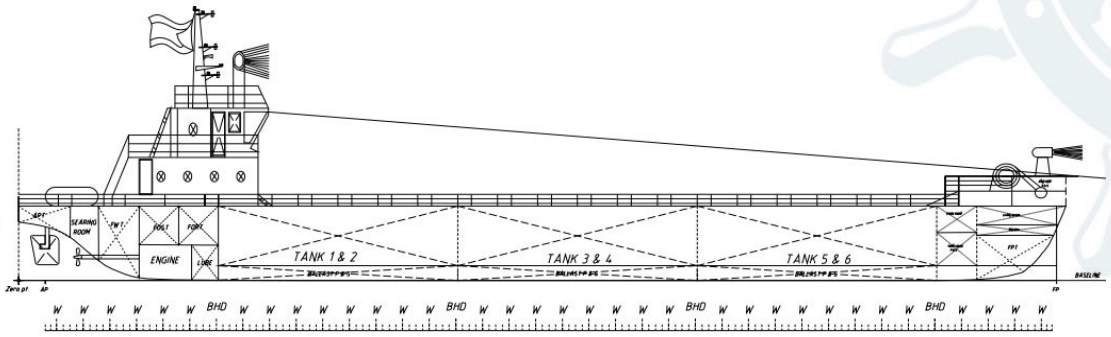
Oil Tanker







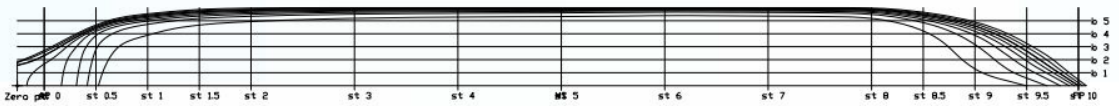




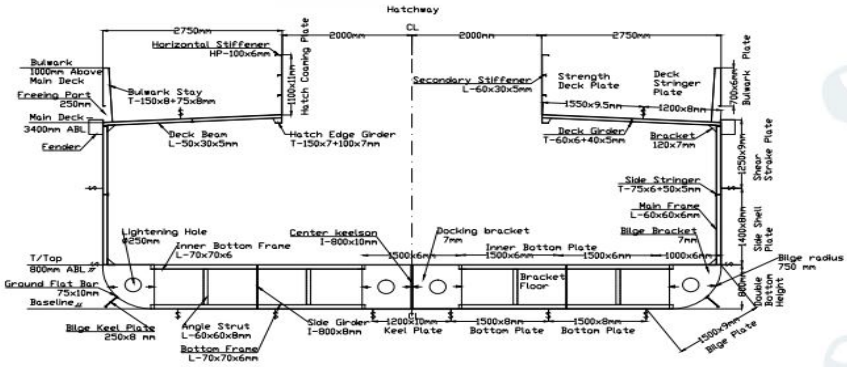
PROFILE

Principal Particulars:			***Designed by:***
LBP	=	50.75 m	❖ Sikder Ariyan Zaman
Breadth, B	=	8.45 m	
Draft, T	=	2.82 m	❖ Organization: **MIST**
C_b	=	0.80	
Cargo Capacity	=	800 tons	

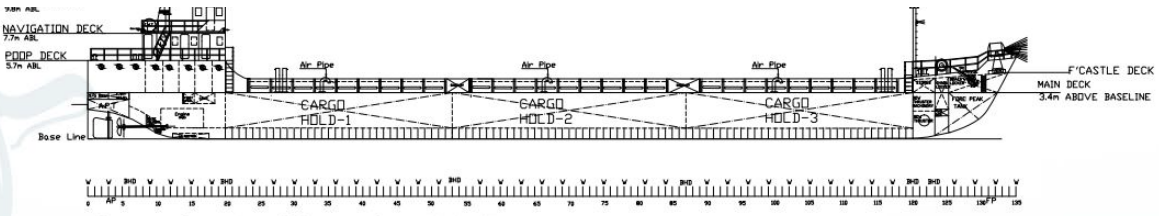
Cargo Ship



Half Breadth



Ordinary Frame

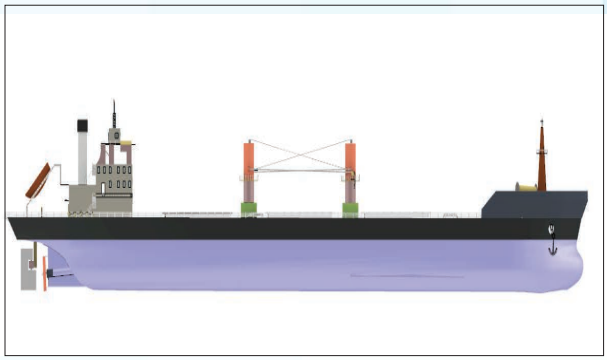


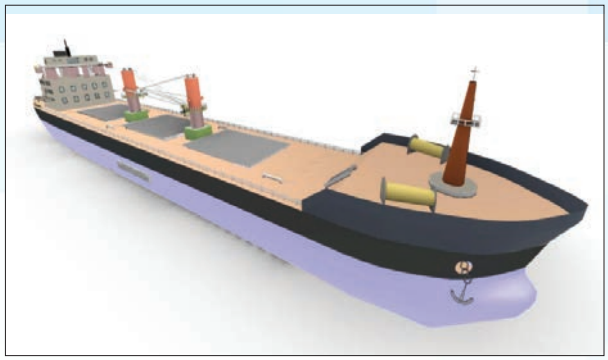
Frame Spacing 500 mm for Main Frame

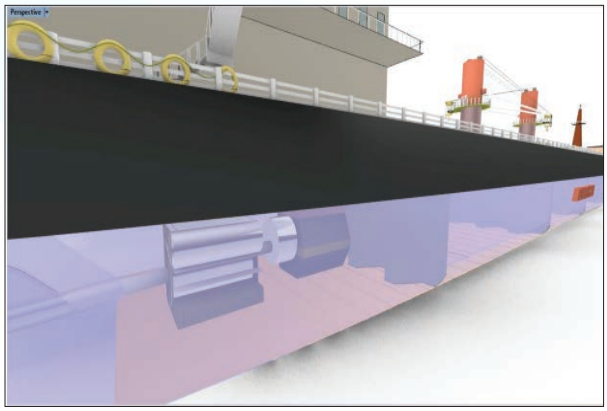
ELEVATION

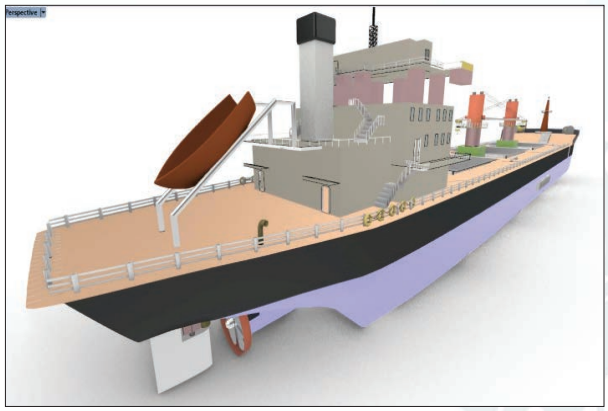
Principal Particulars:			***Designed by:***
LBP	=	64 m	
Breadth, B	=	9.5 m	❖ Maher Niger Prova
Draft, T	=	2.5 m	❖ Md. Yasin Araft
Displacement	=	1200 tons	❖ Organization: **MIST**

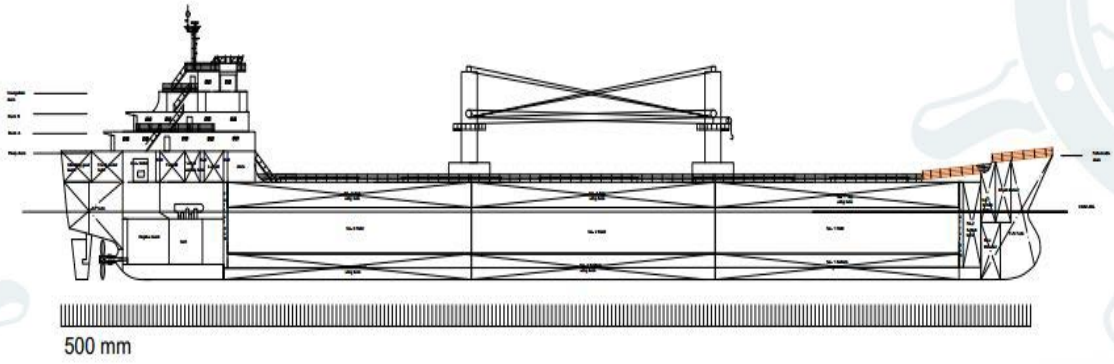
Bulk Carrier







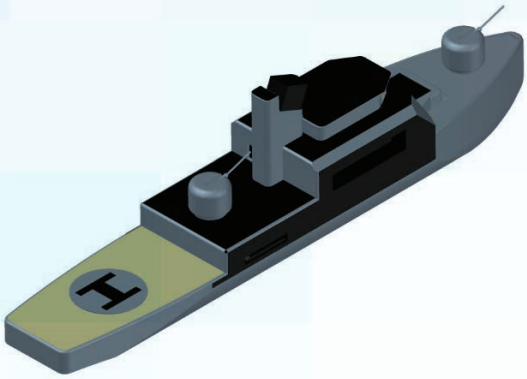


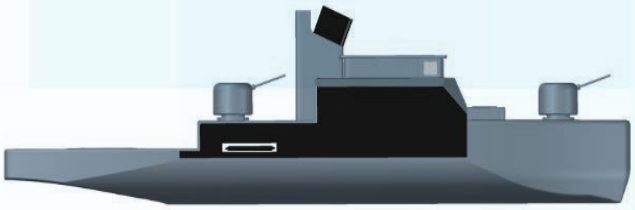


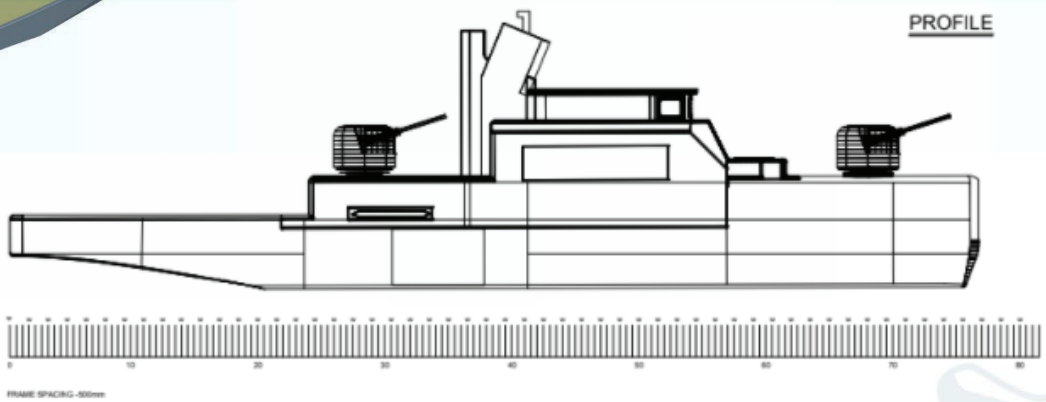
Elevation

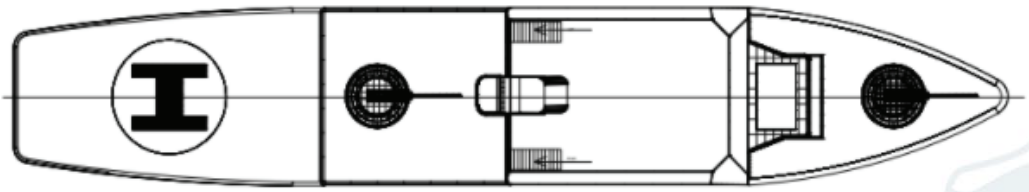
Principal Particulars:			***Designed by:***
LOA	=	149 m	
Breadth, B	=	20.25 m	❖ Loknath Burman
Draft, T	=	8.3 m	❖ Md. Sabbir Ahmed
Displacement	=	19579 tons	❖ Organization**: MIST**

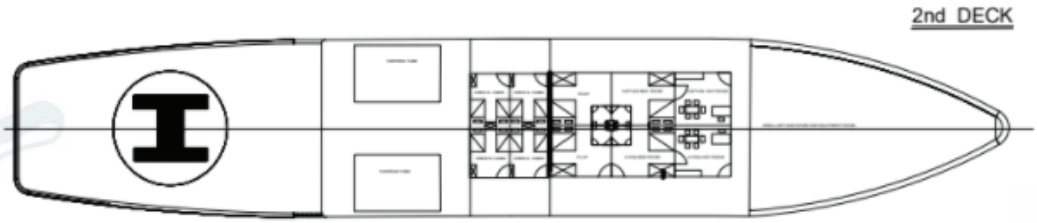
War Ship (Corvette)





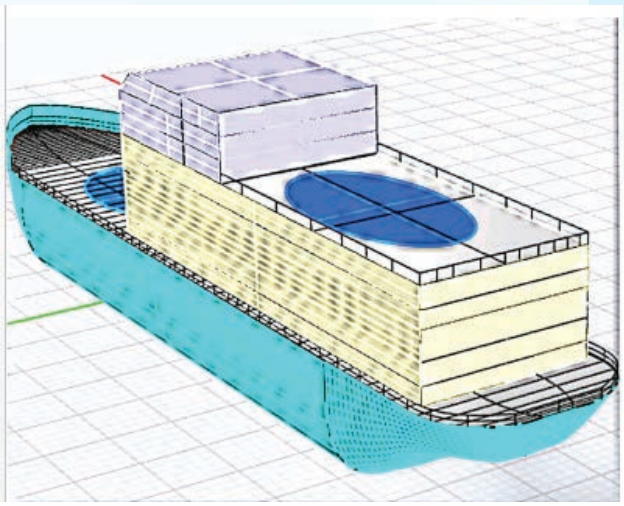


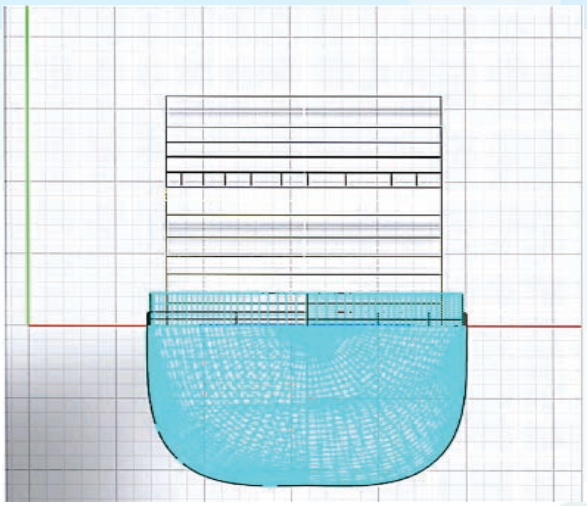


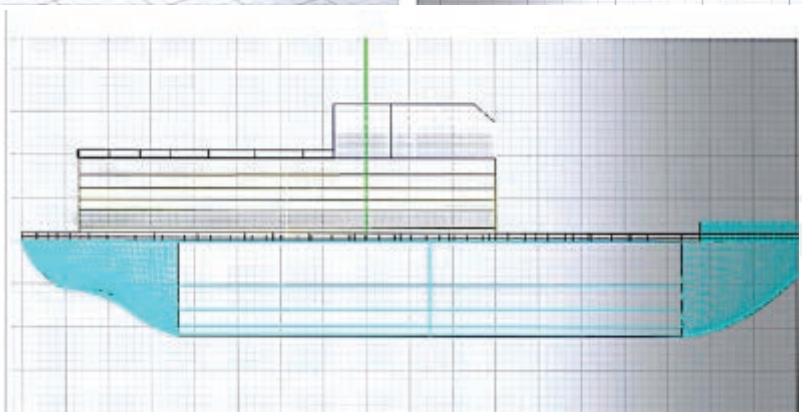


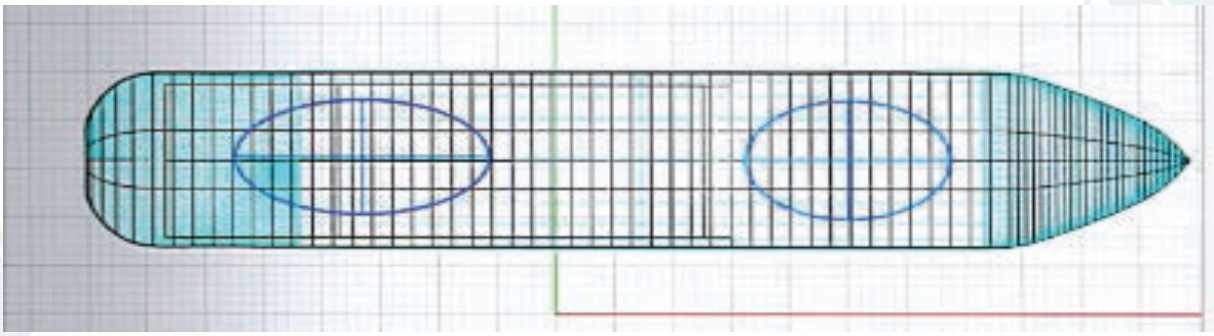
Principal Particulars:			***Designed by:***
LOA	=	76 m	
Breadth, B	=	13.66 m	❖ Shah Md. Newaz Sharif Ahad
Draft, T	=	2.88 m	❖ Organization: **MIST**

Cruise Ship







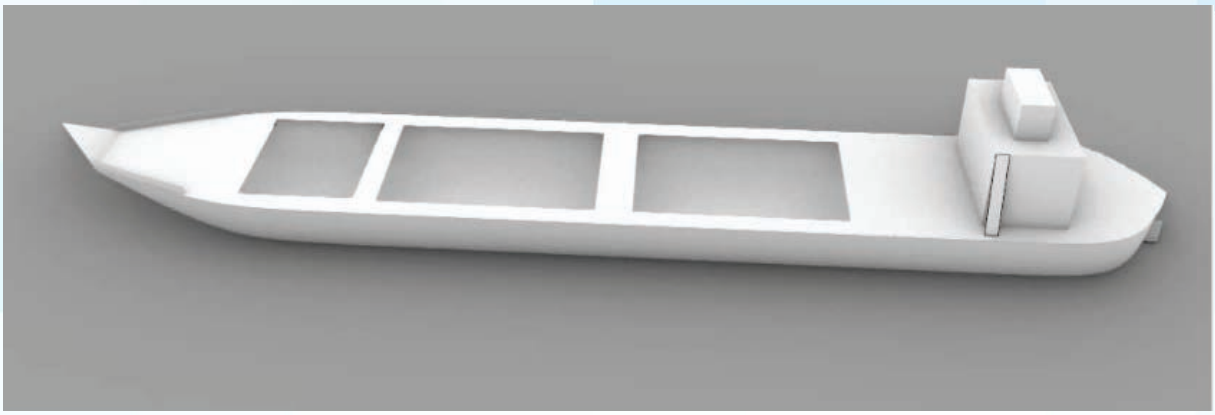


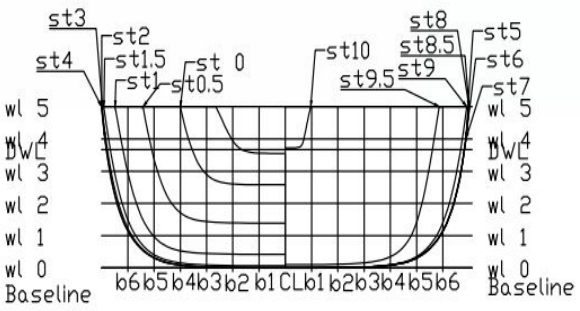
Principal Particulars:		
LBP	=	175 m
Breadth, B	=	25 m
Draft, T	=	10 m
Cb	=	0.81
Displacement	=	34500 tons

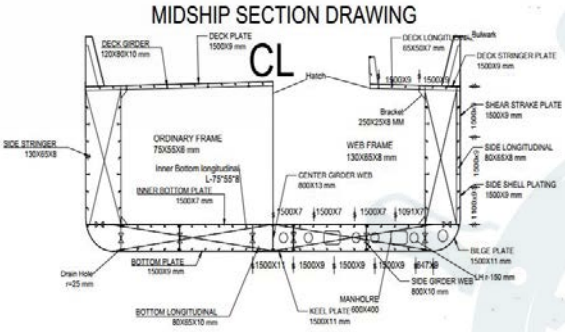
Designed by:

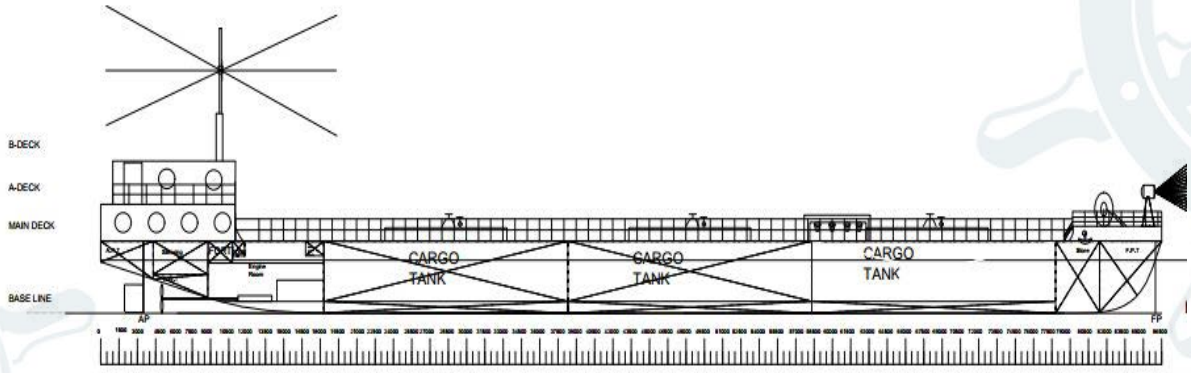
- Iftekhar Uddin Mohammad Afrid
- Organization: **MIST**

Inland Cargo Ship









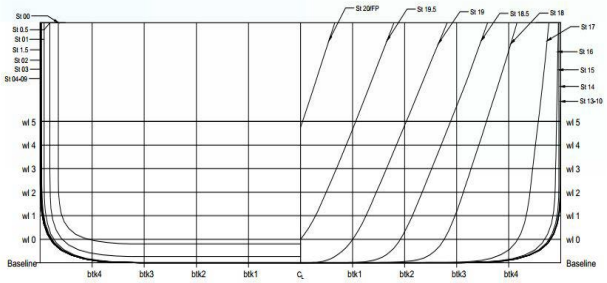
ELEVATION

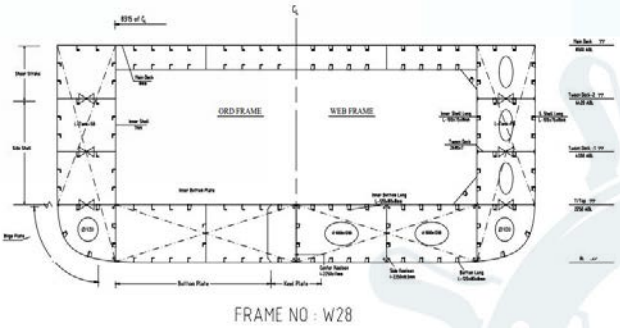
Principal Particulars:		
LOA	=	87 m
Breadth, B	=	13.8 m
Draft, T	=	3.6 m
Speed	=	10.5 knots
C_b	=	0.78
Displacement	=	3267 tons

Designed by:

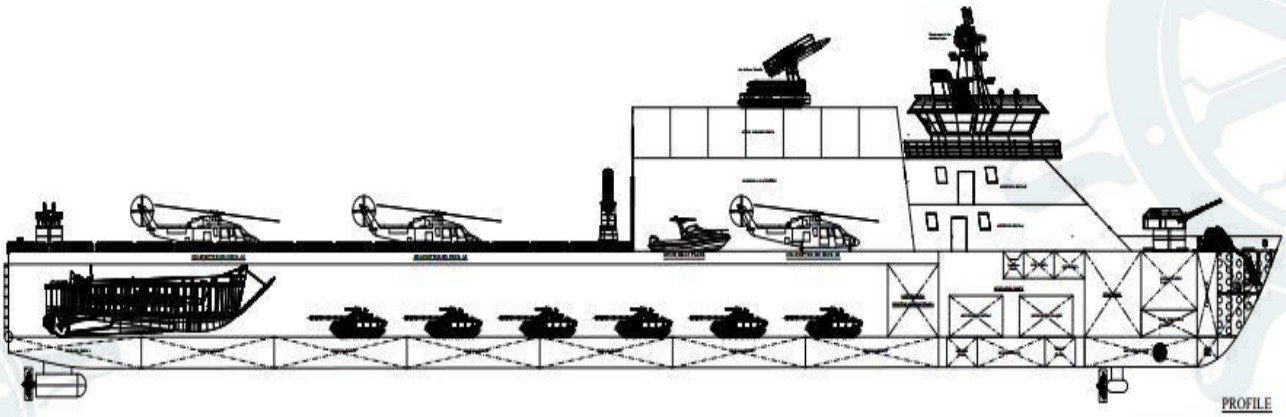
- S M Saimoon Rehan Abdee
- Sakib Hossain Maruf
- Organization: **MIST**

Landing Platform Dock (LPD)





FRAME NO : W28



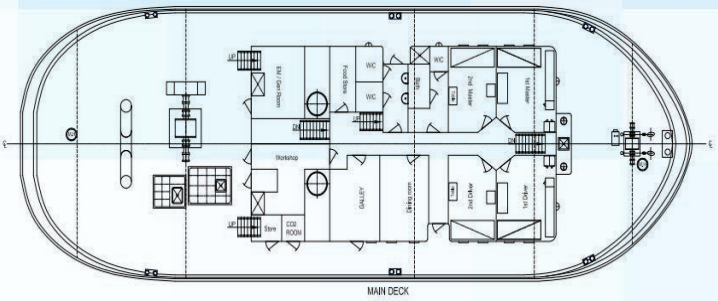
PROFILE

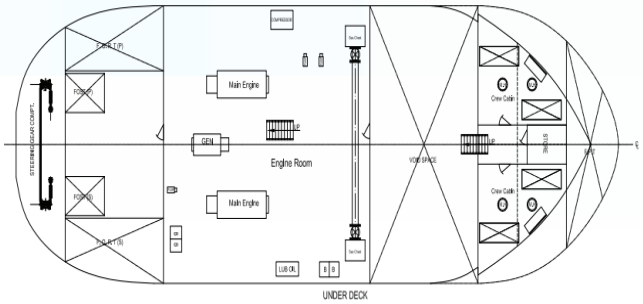
Principal Particulars:		
LOA	=	125 m
Breadth, B	=	22 m
Draft, T	=	5 m
Speed	=	14 knots

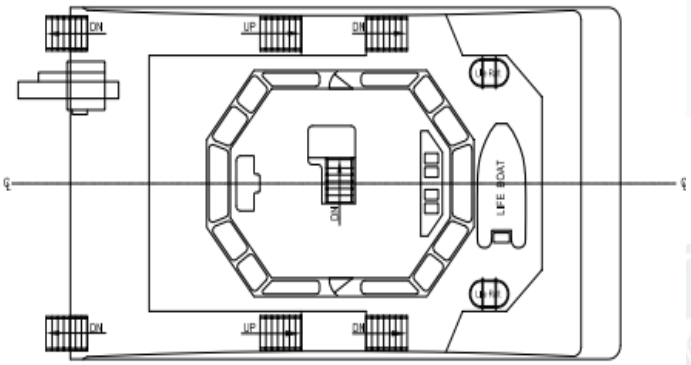
Designed by:

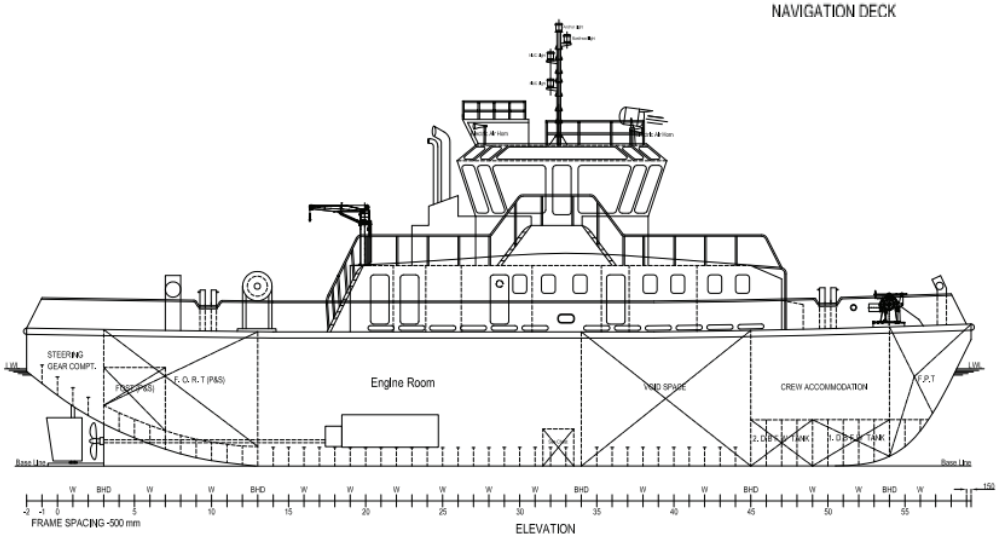
- Md. Hasan Ruhan Rabbi
- Md. Mahmudul Hasan Akib
- Organization: **MIST**

Tug Boat







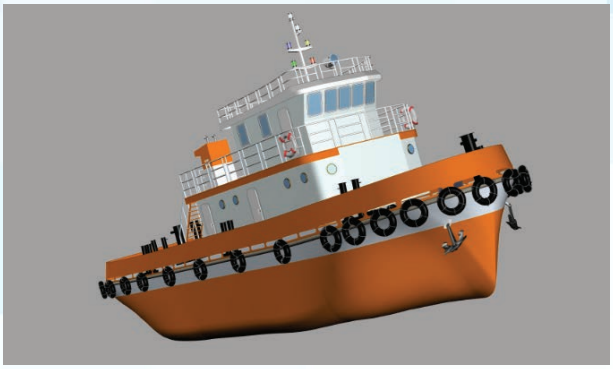


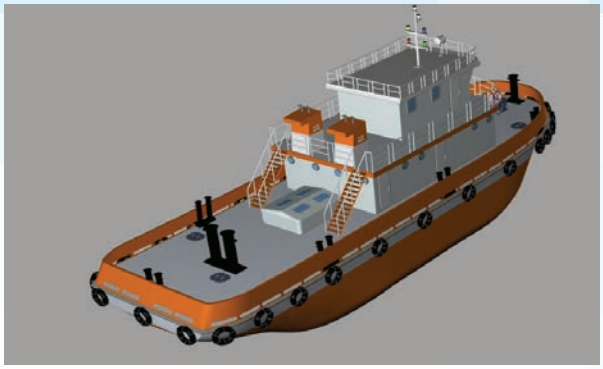
Principal Particulars:		
LOA	=	26.97 m
Breadth, B	=	7.85 m
Draft, T	=	1.9 m
C_b	=	0.54
Bollard Pull	=	11 MT
Displacement	=	202.7 tons

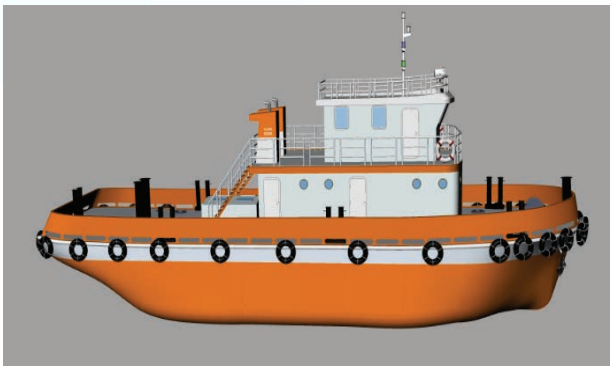
Designed by:

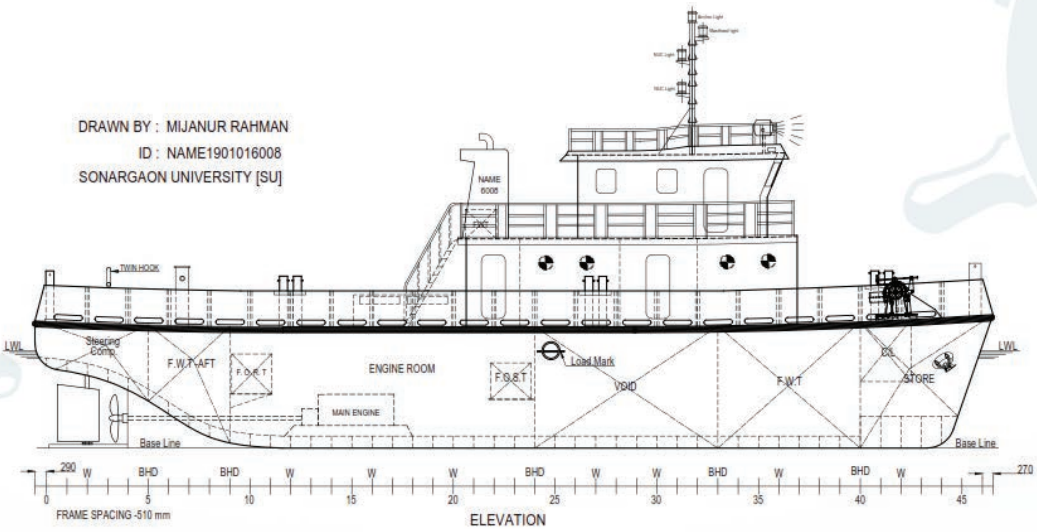
- Md. Abir Hossain
  Doctoral Research Assistant
- University of Texas at Al Paso, **USA**

Passenger Catamaran









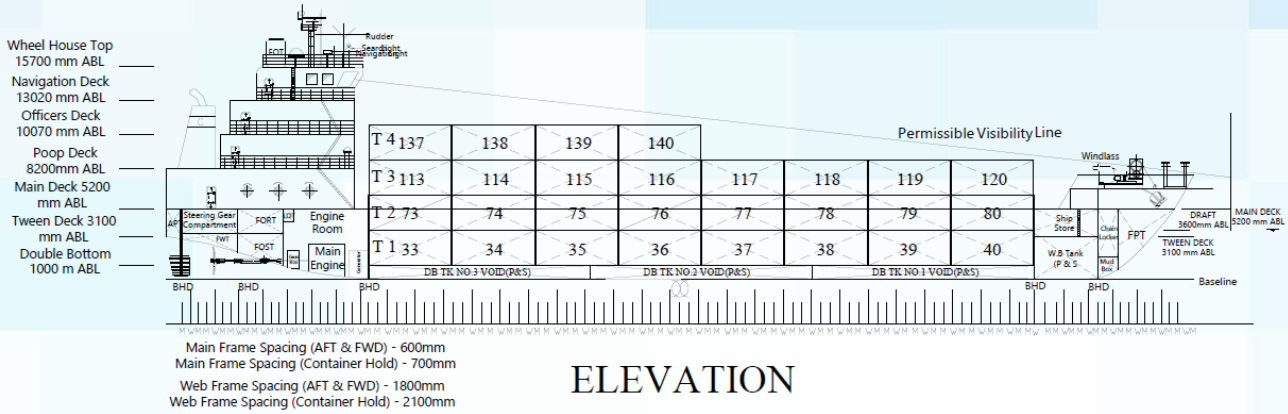
Principal Particulars:

LOA	=	24.02 m
Breadth, B	=	6.7 m
Draft, T	=	2.44 m

Designed by:

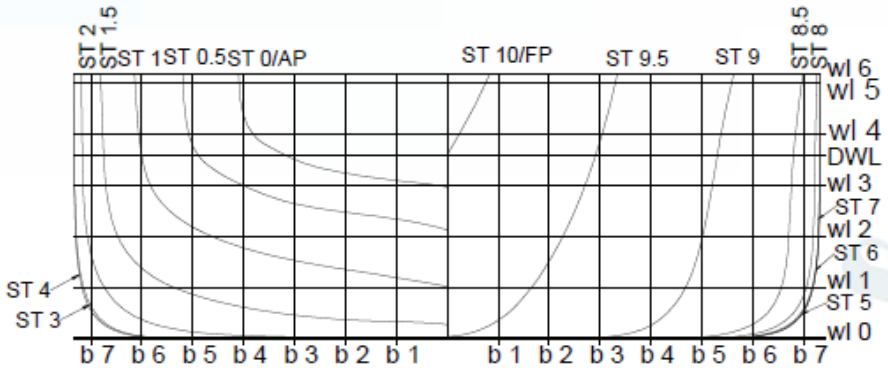
- Mijanur Rahman
- Organization: **Sonargaon University (SU)**

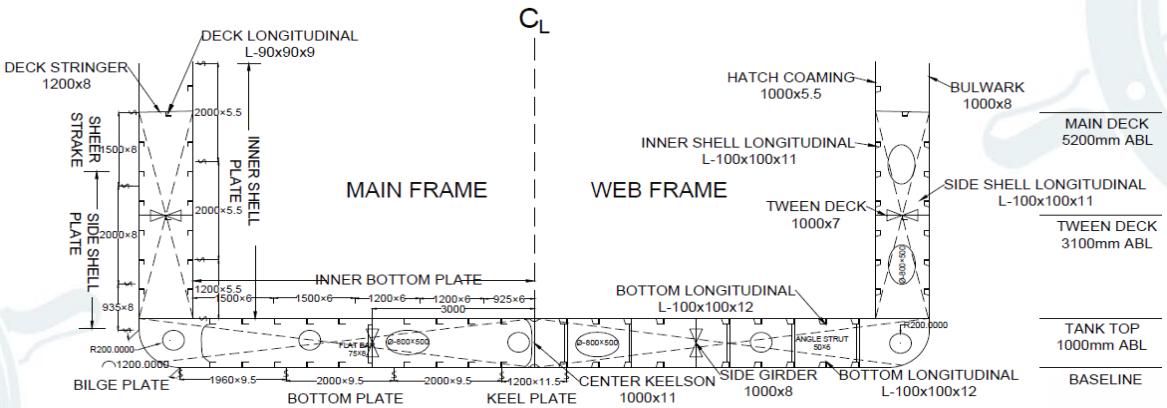
140 TEUs Container Vessel



Main Frame Spacing (AFT & FWD) - 600mm
Main Frame Spacing (Container Hold) - 700mm
Web Frame Spacing (AFT & FWD) - 1800mm
Web Frame Spacing (Container Hold) - 2100mm

ELEVATION



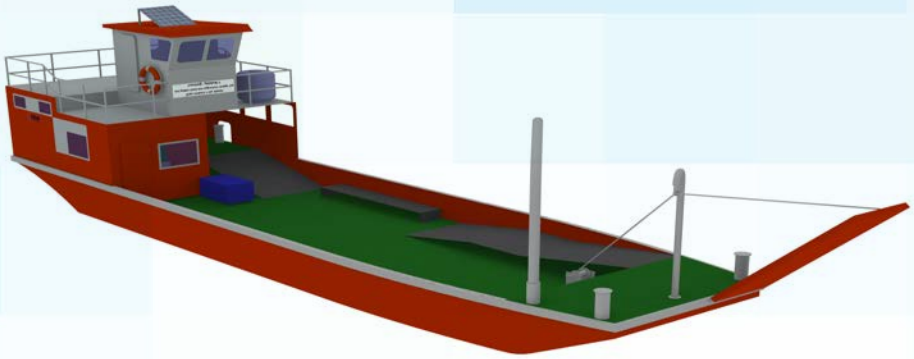


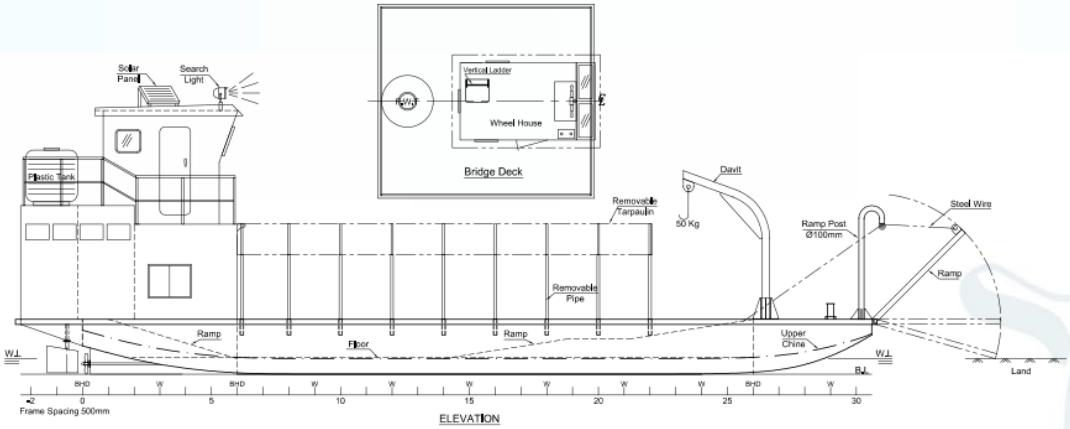
Principal Particulars:		
LOA	=	76.26 m
Breadth, B	=	14.65 m
Depth, D	=	5.20 m
Draft, T	=	3.60 m
Container	=	140 TEUs
C_b	=	0.78

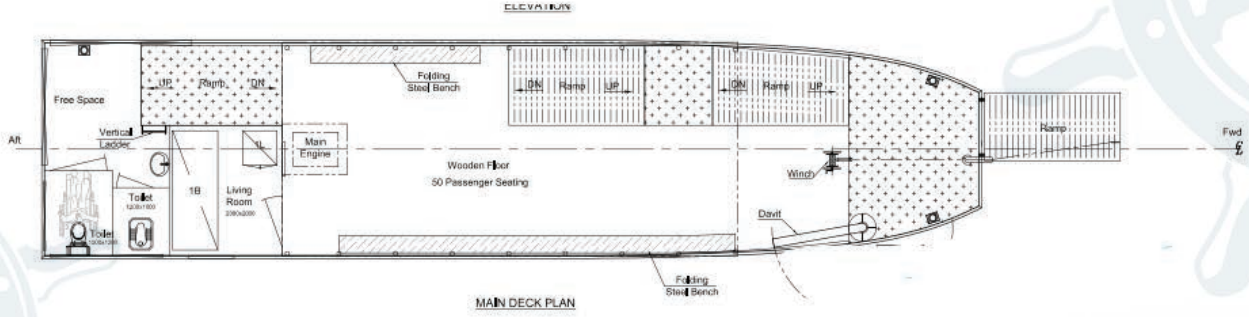
Designed by:

- Monika Akter
- Md. Nahid Hossain
- Organization: **MIST**

Rescue Boat for Remote People





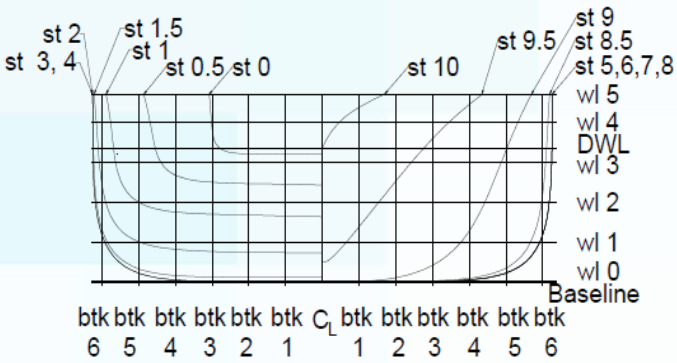


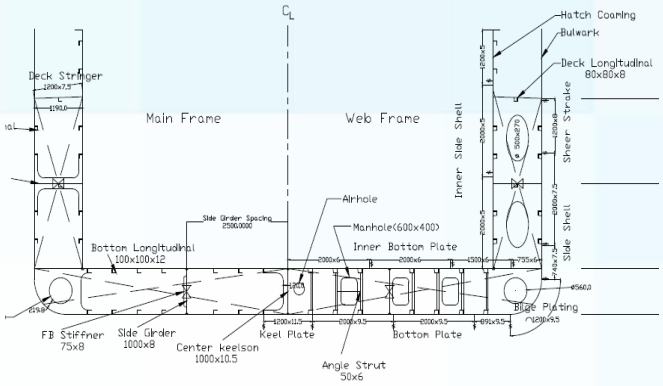
Principal Particulars:		
LOA	=	20.35 m
Breadth, B	=	5.02 m
Depth, D	=	1.05 m
Carrying Capacity	=	100 persons
Speed	=	8 knots

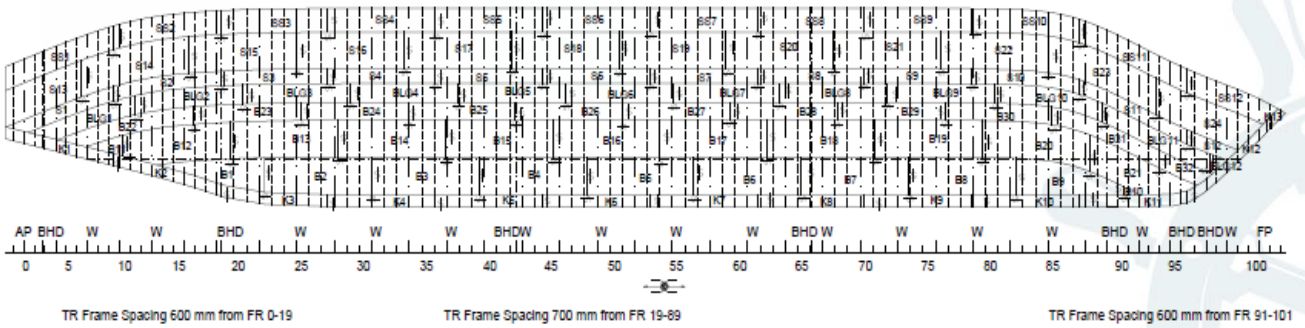
Designed by:

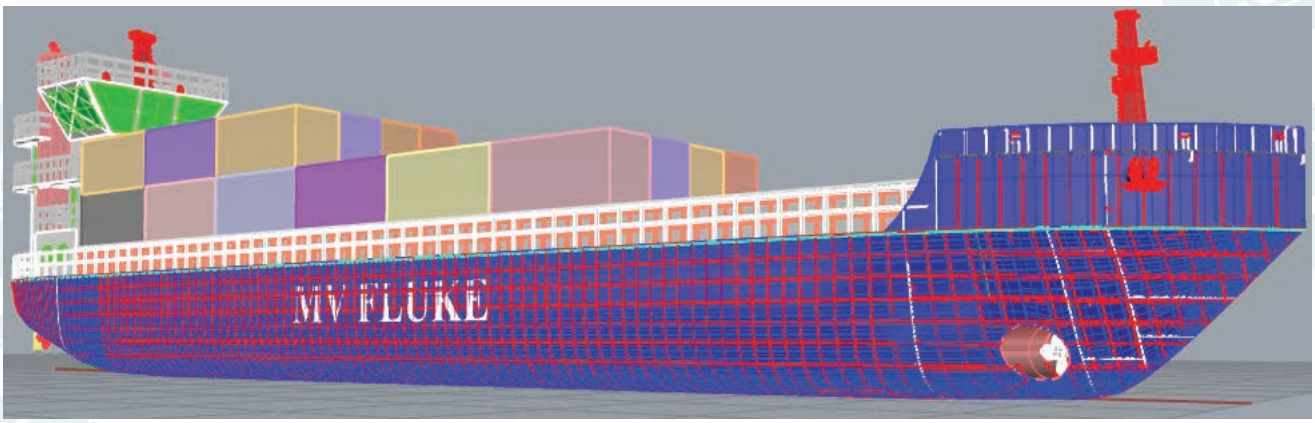
- Sanbera Islam Piuly
  Doctoral Research Assistant
- University of Illinois at Urbana-Champaign, **USA**

100 TEUs Inland Container Vessel









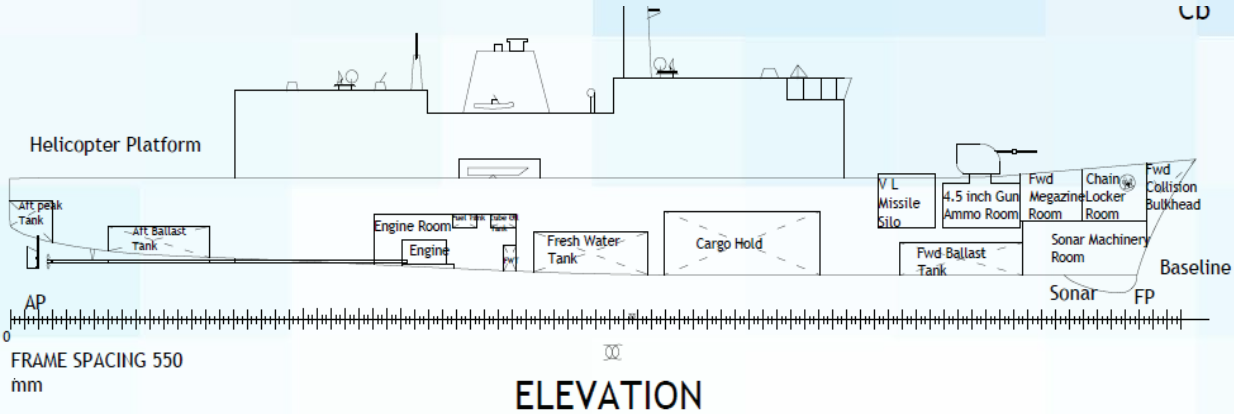
Principal Particulars:

LOA	=	71.50 m
Breadth, B	=	12.51 m
Depth, D	=	4.70 m
Draft, T	=	3.34 m
C_b	=	0.76

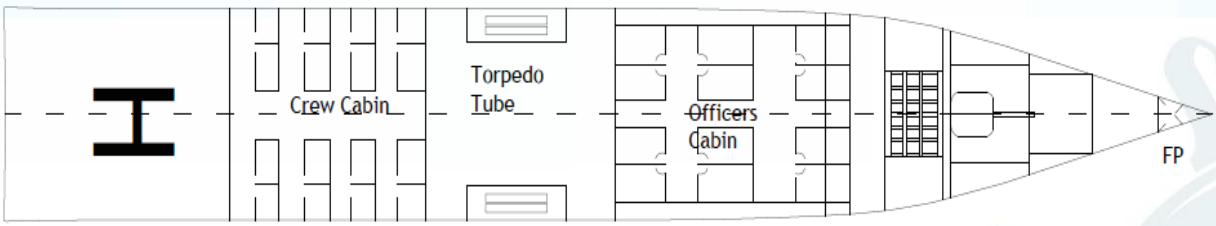
Designed by:

- Iren Naher
- Ridoy Karmoker Rudro
- Organization: **MIST**

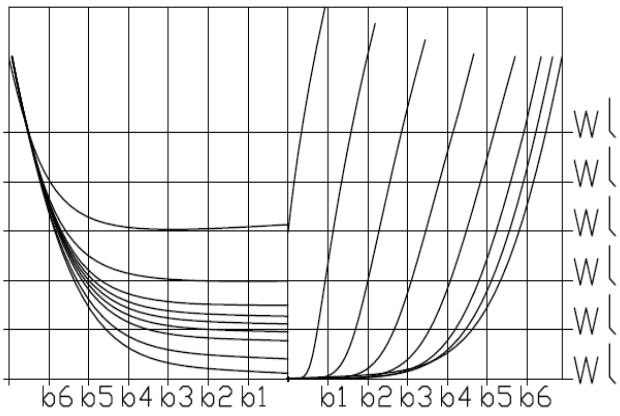
Frigate

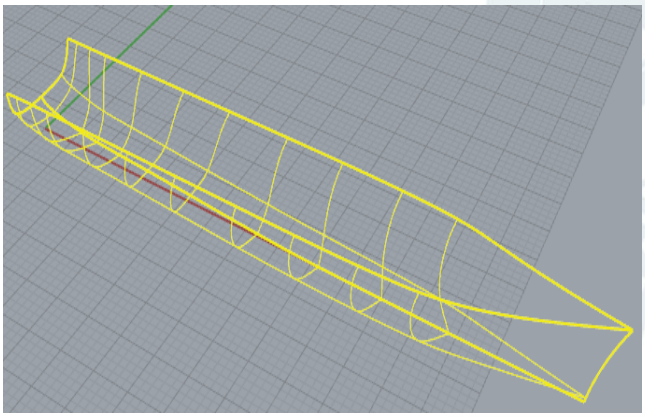


ELEVATION



MAIN DECK



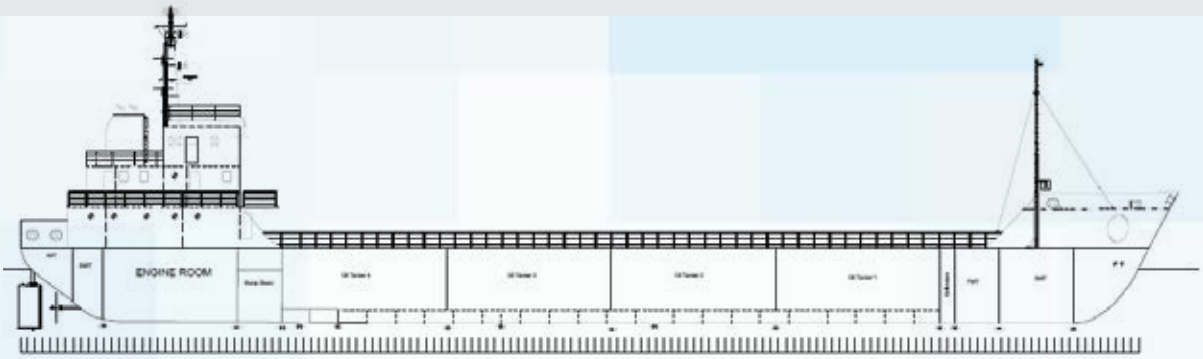


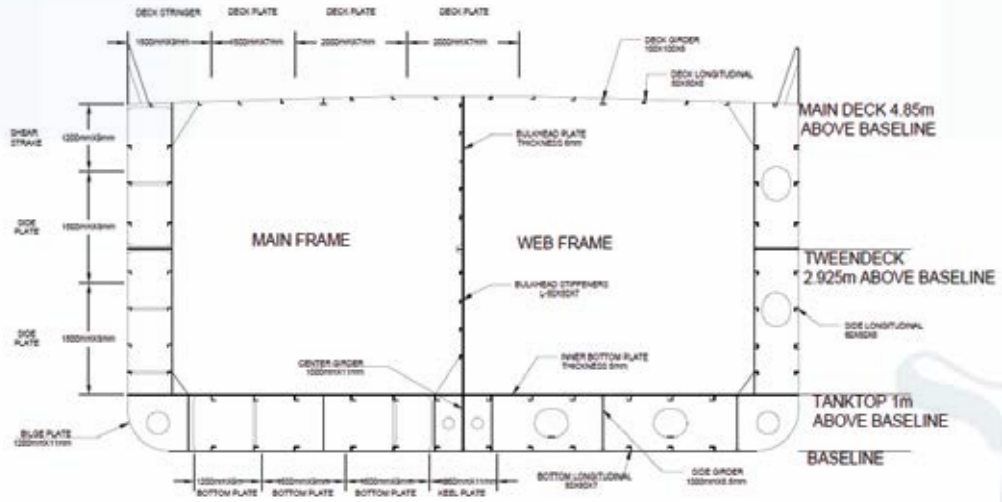
Principal Particulars:		
LOA	=	85.13 m
Breadth, B	=	12.74 m
Depth, D	=	7.80 m
Draft, T	=	3.00 m
C_b	=	0.56
Speed	=	20 Knots

Designed by:

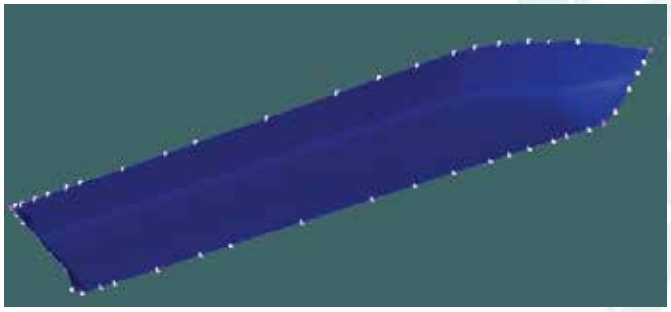
- Rejwan Al Foysal
- Organization: **MIST**

1800 DWT Oil Tanker





BODY PLAN

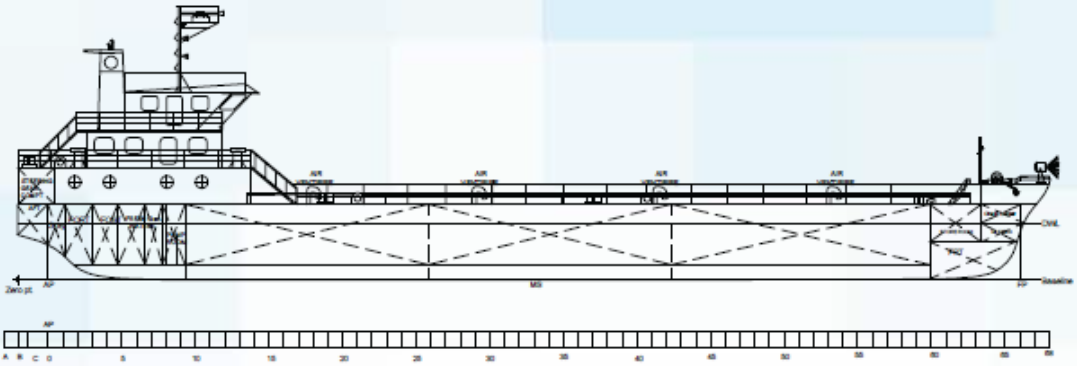


Principal Particulars:		
LOA	=	75.50 m
Breadth, B	=	12.00 m
Depth, D	=	4.85 m
Draft, T	=	3.48 m
C_b	=	0.78
Speed	=	9.50 Knots

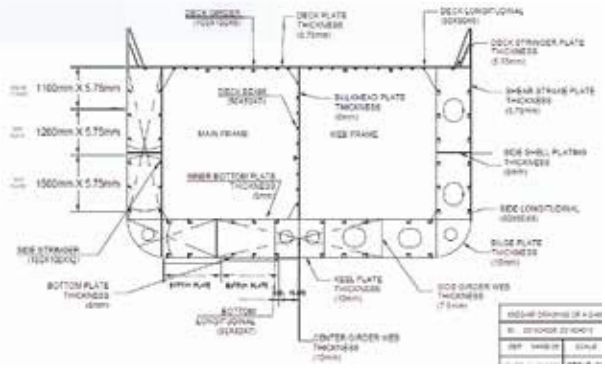
Designed by:

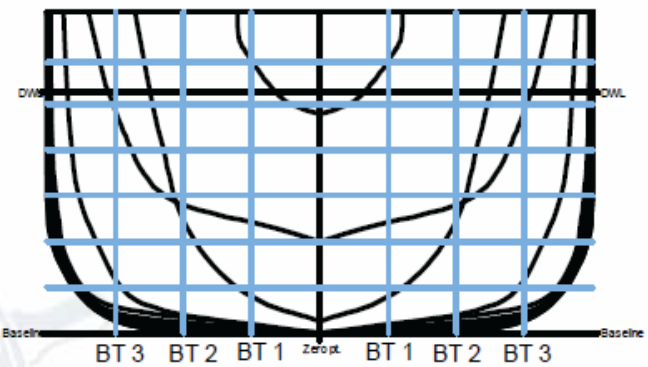
- Sub Lt Shamit
- Md Tamimul Islam Joy
- Md Samiul Islam
- Md Arif Hosen
- Organization: **MIST**

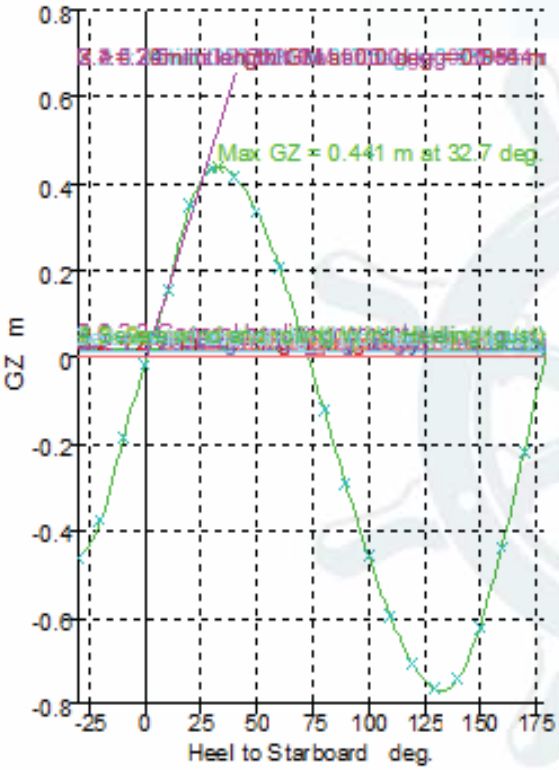
Inland Cargo Vessel



FRAME SPACING AT 500mm THROUGHOUT ELEVATION

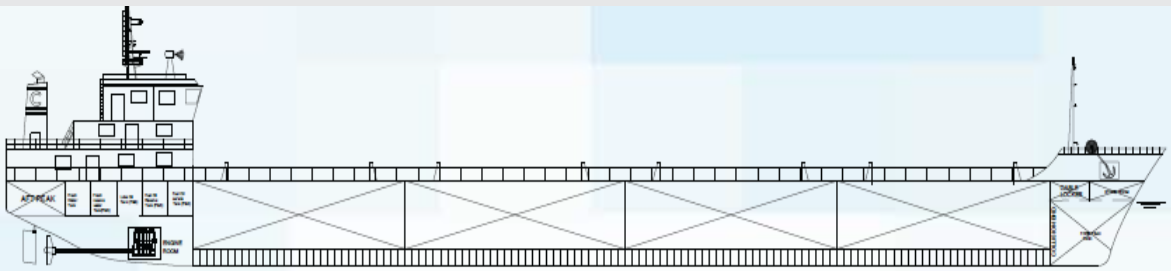


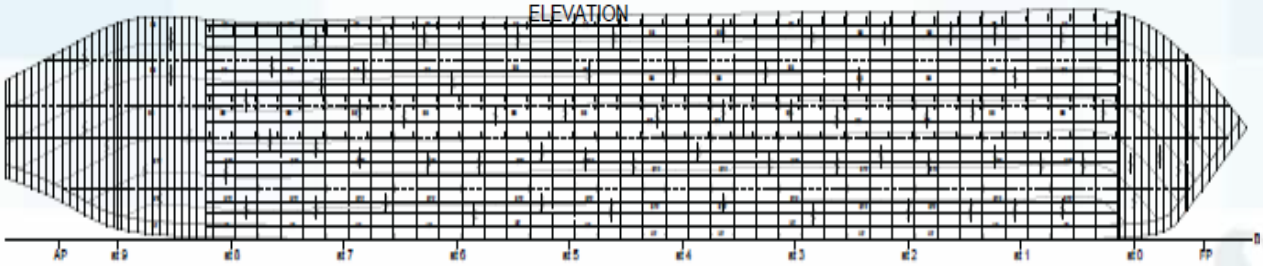


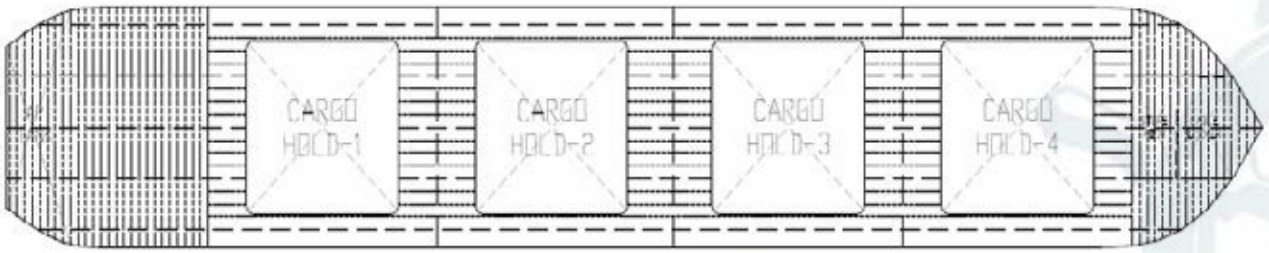


Principal Particulars:			***Designed by:***
LOA	=	67.00 m	❖ Mostafa Galib
Breadth, B	=	9.00 m	❖ Organization: **MIST**
Depth, D	=	5.00 m	
Draft, T	=	3.75 m	
C_b	=	0.83	

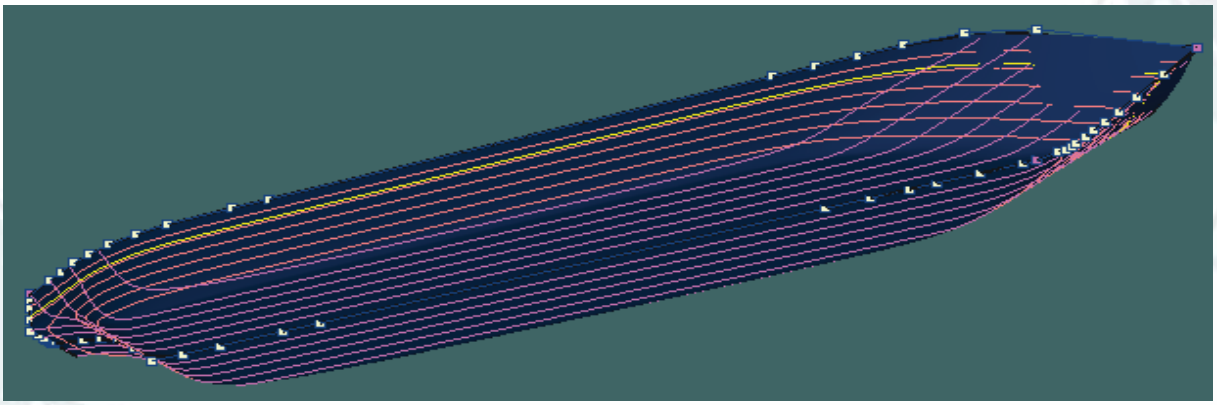
Inland Cargo Vessel





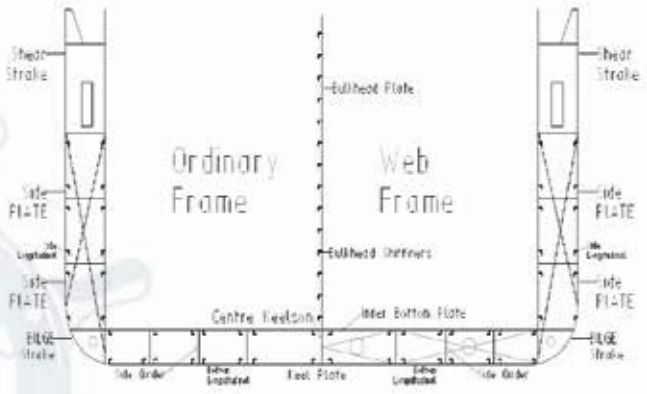


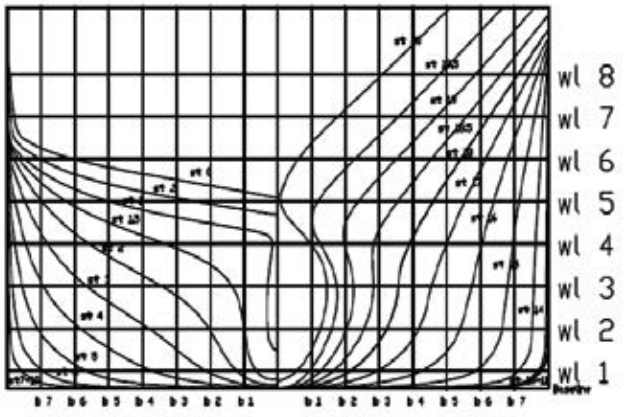
MAIN DECK PLAN



Principal Particulars:			***Designed by:***
LOA	=	79.85 m	❖ Mehedi Anwar
Breadth, B	=	10.82 m	❖ Nafim Yasar
Depth, D	=	5.06 m	❖ Organization: **MIST**
Draft, T	=	3.80 m	
C_b	=	0.75	
Speed	=	12 knots	

1704 TEUs Container Vessel



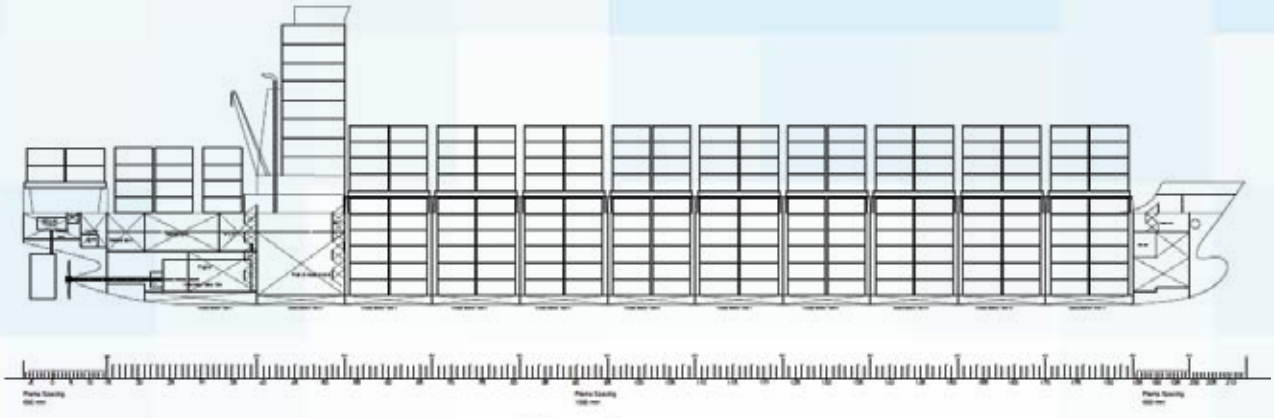


Principal Particulars:		
LOA	=	160.00 m
Breadth, B	=	29.00 m
Depth, D	=	17.00 m
Draft, T	=	8.00 m
C_b	=	0.67
Speed	=	17 knots

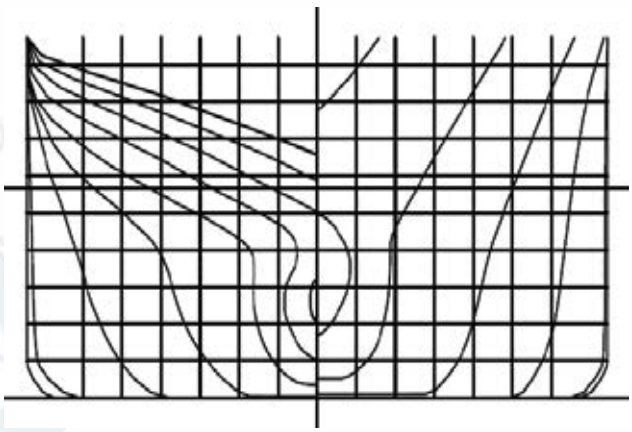
Designed by:

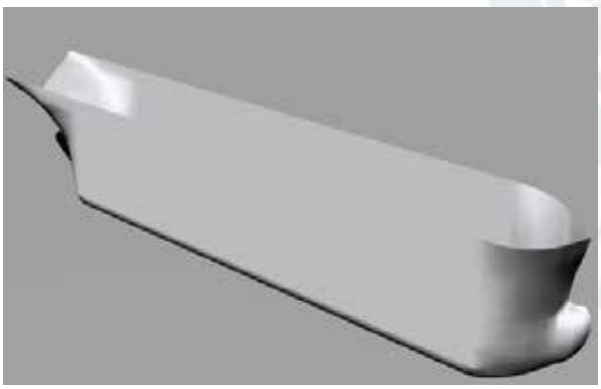
- Tausif Razzak
- Shikder Ariyan Zaman
- Organization: **MIST**

2004 TEUs Container Vessel



Elevation





Principal Particulars:			***Designed by:***
LOA	=	183.40 m	❖ MD. Rabbi Raihan Imon ❖ Organization: **Bangabandhu Sheikh Mujibur Rahman Maritime University**
Breadth, B	=	29.70 m	
Depth, D	=	14.60 m	
Draft, T	=	9.50 m	
C_b	=	0.83	

ACKNOWLEDGEMENT

সুষ্ঠু/নিরাপদ/দুর্ঘটনামুক্ত নৌচলাচলের লক্ষে করণীয়

"মুজিব বর্ষের অঙ্গীকার
নদী রাখবো পরিষ্কার"

যাত্রীদের প্রতি ঃ

জরুরী প্রয়োজনে যোগাযোগ: হটলাইন ১৬১১৩

- নৌযাত্রাকালে অবৈধ, রেজিস্ট্রেশন/সার্ভে (ফিটনেস)/রুটপারমিট বিহীন ও ঝুঁকিপূর্ণ নৌযান (লঞ্চ, ট্রলার, স্পীডবোট ও অন্যান্য) পরিহার করুন।
- নৌযানে ভ্রমণকালে লাইফ জ্যাকেট পরিধান করুন।
- অতিরিক্ত যাত্রী হয়ে লঞ্চ ভ্রমণ করবেন না, লঞ্চের ছাদে উঠবেন না।
- আবহাওয়ার পূর্বাভাস জেনে যাত্রা করুন। দুর্যোগপূর্ণ আবহাওয়ায় লঞ্চে যাত্রা করবেন না।
- দুর্যোগপূর্ণ আবহাওয়া দেখা দিলে আপনার যাত্রা বাতিল করুন। কোন অবস্থায় জীবনের ঝুঁকি নেবেন না।

- পথিমধ্যে হঠাৎ দুর্যোগপূর্ণ আবহাওয়া শুরু হলে লঞ্চে এদিক সেদিক ছুটাছুটি না করে জীবন রক্ষাকারী সরঞ্জামাদি হাতের নাগালে রেখে সতর্কাবস্থায় থাকুন এবং মহান সৃষ্টিকর্তাকে স্মরণ করুণ।

চালকদের প্রতি ঃ

জরুরী প্রয়োজনে যোগাযোগ: হটলাইন ১৬১১৩

- অভ্যন্তরীণ নৌপথে অবৈধ, রেজিস্ট্রেশন/সার্ভে (ফিটনেস)/রুটপারমিট বিহীন ও ঝুঁকিপূর্ণ নৌযান (লঞ্চ, ট্রলার, স্পীডবোট, মালবাহী নৌযান ও অন্যান্য) পরিচালনা করবেন না।
- নৌযানে (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো জাহাজ, বাল্কহেড ও অন্যান্য) ধারণ ক্ষমতার অতিরিক্ত যাত্রী ও মালামাল বহন করবেন না; অতিরিক্ত যাত্রী ও মালামাল বোঝাই দুর্ঘটনা ঘটার অন্যতম কারণ।
- দুর্যোগপূর্ণ আবহাওয়ায় নৌযান (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো জাহাজ, বাল্কহেড ও অন্যান্য) পরিচালনা করবেন না।
- স্পীডবোট ও ছোট নৌযান পরিচালনাকালে যাত্রীদের লাইফ জ্যাকেট পরিধান নিশ্চিত করুন।
- যাত্রার পূর্বে ইঞ্জিন ভালোভাবে পরীক্ষা করে এবং আবহাওয়া সংকেত জেনে লঞ্চ পরিচালনা করুন।
- যাত্রার পূর্বে হ্যাচ কভার পানিরোধক করে ভালোভাবে বন্ধ করুণ যাতে হ্যাচে পানি বা বাতাস ঢুকতে না পারে।
- লঞ্চে পর্যাপ্ত সংখ্যক জীবন রক্ষাকারী সরঞ্জামাদি (লাইফ জ্যাকেট, লাইফ বয়া ও অগ্নিনির্বাপক সরঞ্জামাদি ইত্যাদি) রাখুন।
- মাঝ নদীতে লঞ্চ রেখে নৌকায় করে যাত্রী উঠা/ নামা করাবেন না।
- করোনা ভাইরাস (COVID-19) জনিত রোগ বিস্তার রোধে লঞ্চে আরোহনকৃত প্রত্যেক যাত্রীর মুখে মাস্ক পরিধানসহ সামাজিক দূরত্ব বজায় রেখে ভ্রমণের বিষয়টি নিশ্চিত করুন।

মালিকদের প্রতিঃ

জরুরী প্রয়োজনে যোগাযোগ: হটলাইন ১৬১১৩

- অনুগ্রহ করে নৌযান নিবন্ধন (রেজিস্ট্রেশন ও সার্ভে) করুন। নিবন্ধনের জন্য নৌপরিবহন অধিদপ্তর/নিকটস্থ নদী বন্দর কার্যালয়ে যোগাযোগ করুন।
- অবৈধ, রেজিস্ট্রেশন/সার্ভে (ফিটনেস)/রুটপারমিট বিহীন ও ঝুঁকিপূর্ণ নৌযান (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো জাহাজ, বাল্কহেড ও অন্যান্য) পরিচালনা থেকে বিরত থাকুন।
- যাত্রী সাধারণের জানমালের নিরাপত্তা বিধান করা আপনার নৈতিক দায়িত্ব ও কর্তব্য। তাই উপযুক্ত সনদধারী এবং নির্ধারিত সংখ্যক মাস্টার ও ড্রাইভার দ্বারা লঞ্চ পরিচালনা করুন।
- নৌযানে যাতে অতিরিক্ত যাত্রী নেয়া না হয় সে লক্ষ্যে নিজ নিজ নৌযান/ লঞ্চের প্রতি সতর্ক দৃষ্টি রাখুন।
- নৌযানে পর্যাপ্ত সংখ্যক জীবনরক্ষাকারী সরঞ্জামাদি (লাইফ জ্যাকেট, লাইফ বয়া, অগ্নিনির্বাপক সরঞ্জামাদি ইত্যাদি) মজুদ রাখুন।
- করোনা ভাইরাস (COVID-19) জনিত রোগ বিস্তার রোধে সরকার কর্তৃক জারীকৃত সকল নির্দেশনা অনুসরণ করে লঞ্চ/ নৌযান পরিচালনা করুণ।
- প্রতিটি লঞ্চে রেডিও ও মোবাইল ফোন সরবরাহ করুণ। দুর্যোগপূর্ণ আবহাওয়ায় নৌযানের মাস্টারের সাথে পুনঃপুনঃ যোগাযোগ রক্ষা করে সার্বিক বিষয় কঠোরভাবে মনিটর করবেন।

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- Supervision of constructions of different types of dredgers
- Supervision of constructions of different types of ships
- Preparation of proposals for construction of different types of ships
- Technical advice for marine construction
- Feasibility study of different types of ships and boats
- Technical advice and consultancy services for ship borne portable and fixed firefighting systems.

CATS-MIST (NAME) has provided consultancy service successfully in

- Procurement of CSD, various ancillary vessels and other accessories for BIWTA
- Feasibility study for procurement of 02 nos. High speed patrol and pilot vessels for Chittagong Port Authority (CPA)
- Procurement of 02 nos. CSD for CPA

Department of Naval Architecture and Marine Engineering, MIST
Mirpur Cantonment, Dhaka-1216
Webiste: https://www.mist.ac.bd/department/name;
Email: head@name.mist.ac.bd Contact No: 01769024096

Believe in Quality, Time and Customer Satisfaction

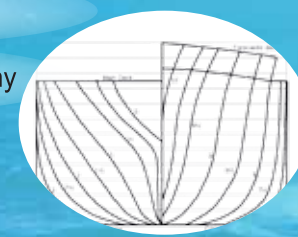
Shipbuilding

Chittagong Dry Dock Ltd.

Bangladesh Navy

An ISO 9001:2015 Certified Company

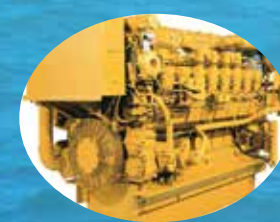
Jetty Service and Berthing Facility



Ship Design

Heavy Steel Engineering

Ship Repair & Renovation



Import & Export

44 Years Experience in Business

Area of Business

- Shipbuilding
- Ship Design
- Ship Repair & Renovation
- Heavy Steel Engineering
- Civil Engineering Works
- Jetty Service and Berthing Facility
- Import and Export
- Consultancy
- C&F

Unique Facilities

- Only Dry Dock in Bangladesh
- The largest ship repair facilities with 183 meter grave dock that can dock vessels up to 22,000 DWT
- Strategic location - within Chittagong Port premises
- Good communication in all three modes of transportation (Road, Sea & Air)
- Sufficient depth of water (9.5 meter) for launching large vessel
- 342 m long Jetty for berthing and outfitting of ships
- Direct access to the sea
- Facility to load and unload all types of cargo at own Jetty
- Experienced and skilled work force

Vision: To become the leading shipbuilding company in Bangladesh

Chittagong Dry Dock Ltd, East Patenga, Chattogram
● Telephone: 031-2501112 ● Fax: 031-2501123 ● E-mail: drydock.bd@gmail.com ● Web: www.cddl.gov.bd ●

Motor Transport Workshop

It is a subsidiary workshop of Khulna Shipyard Ltd. It is situated inside BNS ISSA KHAN base, New Mooring, Chattagram. All kinds of vehicle maintenance support, servicing and repair works are carried out with advance technology and skilled manpower. It offers best possible services to customers for attaining their full satisfaction.

খুশিলি রাবার ফ্যাক্টরী

রাবার যন্ত্রাংশ তৈরীর বিশ্বস্ত প্রতিষ্ঠান

মান সম্মত রাবার যন্ত্রাংশ সরবরাহের মাধ্যমে কাস্টমারের সন্তুষ্টি অর্জনই আমাদের একমাত্র লক্ষ্য

- স্যাম্পল অথবা ড্রইং প্রাপ্তি সাপেক্ষে যে কোন ধরণের রাবার স্পেয়ার্স তৈরী করা হয়।
- উন্নত কাঁচামাল ব্যবহার করে আন্তর্জাতিক মানের বিদেশী মেশিনে প্রতিটি রাবার স্পেয়ার্স তৈরী করা হয়।
- আধুনিক ল্যাবরেটরীতে প্রতিটি রাবার স্পেয়ার্স নিরীক্ষার মাধ্যমে মান নিয়ন্ত্রণ করা হয়।
- প্রতিটি রাবার আইটেম কোয়ালিটি কন্ট্রোল সেল দ্বারা Qualified হওয়া সাপেক্ষে সরবরাহ করা হয়।
- আমাদের কার্যক্রম আন্তর্জাতিক ক্লাসিফিকেশন সোসাইটি **Bureau Veritas** দ্বারা সনদ প্রাপ্ত।

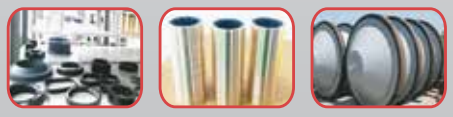
আমাদের প্রোডাক্ট সম্ভারঃ

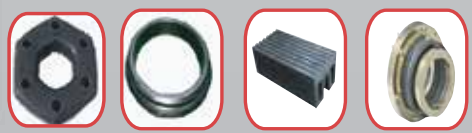
* রাবার কাটলাস বুশ * O - রিং সিল * ডিপ সী সিল *জেটি ফেন্ডার (D/ W/ Rectangular Type) * সিলিন্ড্রিক্যাল ফেন্ডার * আর্ক ফেন্ডার * সেল ফেন্ডার * ইঞ্জিন মাউন্টিং * শেয়ার টাইপ মাউন্টিং * ওয়েল সীল * রাবার ইমপেলার * রাবার বেলুস * রাবার লিপ সীল *ডোর/ হ্যাচ/ পোর্ট হোল * নিউমেটিক ব্লাডার * গ্যাসকেট ইত্যাদি





RECOGNITION FOR
BV MODE II SCHEME
KSY Rubber Factory
Khulna - BANGLADESH





KSY RUBBER FACTORY
KHULNA SHIPYARD LIMITED
BANGLADESH NAVY, KHULNA

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