Preface

The main objective of this book is to disseminate the work of experts with different backgrounds, experience, and interests in the areas of marine science, engineering, and technology for sustainable development in the maritime industry. Academic and research institutions, students, and professors in marine fields will find this book useful. We believe that presenting diverse opinions makes the book contents richer and more informative and beneficial to the readers.

The book contains several chapters written by maritime academics and experts with diverse views on maritime issues. The book is divided into four sections. Section one presents the issues at the center of technology, energy, and the environment: issues related to energy and environment requirements for the marine industry. An alternative energy, design, and operational emission control measures approach is presented. The second section presents marine technology and pollution prevention, protection, and control issues. Chapters related to climate change control, ozone depletion control, coastal preservation, corrosion prevention, ecology, and sustainable exploration of the sea are presented. In the third section, marine transportation management, policy, electronics navigation, logistics, and regulations for a sustainable marine transportation system are discussed. Section four describes the material on maritime education and training, the significance of human factors and human errors in sustainable development, the assessment of human reliability, and the importance of using simulation outcomes and human behavior as part of design objectives for sustainable systems. Across all chapters issues related to sustainable development practices and employing risk-based designs towards better competitive and sustainable systems are also presented.

Section 1, “Maritime Technology, Energy, and the Environment,” begins with Chapter 1, “Solar Hybrid Power System for Marine Diesel Engine: UMT Vessel Experience.” Like all modes of transportation that use fossil fuels, ships produce carbon dioxide emissions that significantly contribute to global climate change and ocean acidification. Additionally, ships release other pollutants that also contribute to the problem and exacerbate climate change. Considering the large volume of ships on the high seas, ship emissions pose a significant threat to human health. The ocean is exposed to vast amounts of sunrays and has a great potential to be explored by the maritime sector and green power industry. Solar energy hybrid assisted power to support auxiliary power for the instruments on board the vessel is explored in a UMT vessel. The vessel that is used in this case study is Discovery XI, which is a 16.50 meter diving boat owned by University Malaysia Terengganu. The study explores the feasibility of using solar energy as a supporting power for marine vessel auxiliaries. The reduction of fuel usage after installing the solar PV system on the boat is determined, as well as an economic analysis. The power requirement for the vessel’s electrical system is estimated. The fuel and money saved is also estimated for comparison purposes of the vessel using the solar PV system and the vessel without the PV system. Economic analyses are performed, the Annual Average Cost (AAC) between a vessel using solar PV system and
a vessel without solar PV system is estimated, and the period of the return of investment for the vessel with solar PV system is also estimated. The use of a photovoltaic solar system to assist the boat power requirement will benefit the environment through Green House Gas (GHG) reduction, and the use of solar as a supporting alternative energy could cut the cost of boat operation through fuel savings.

Chapter 2 is “Development of Mono and Multihull Resistance Sustainable Marine Technology Development and Green Innovation.” During the last decade, multihull ships have rapidly evolved into a dominant mode of sea transportation. Their particular area of proliferation is in short sea shipping where they show considerable superiority over competitive designs in attributes such as power requirements, economy, space availability, and sea keeping quality. The rapid growth of the market has led to the need for an expanded range of multihull designs in terms of size, speed, and payload diversity (passengers, vehicles, containers). However, even now there is a scarcity of publicly available preliminary design tools for multihull vessels. This fact hinders the ship owner and naval architect from being able to quickly assess the relative merit of alternative potential designs without having to resort to expensive expert consultancy solutions.

Chapter 3 is “Technical Fuel Conservation: Hull and Propeller Performance.” Hull and propeller performance monitoring is receiving more attention now than at any time in tanker industry history. The advent of new hull coating systems in connection with bunker prices and emission reduction initiatives has led to new scientifically sound metrics for evaluating the efficiency of drydock treatment, comparing hull coating systems on similar tanker types and determining economically optimal intervals for in-water husbandry. This chapter describes how technical fuel conservation policy, including a hull and propeller performance monitoring system, leads to enhanced vessel efficiency. Success of such a policy requires a tanker organization to employ a strong integration of efficiency metrics with daily operational policy and procedures. An example of such a policy: “It is the tanker company policy that the fuel consumption and the corresponding emissions shall be reduced as much as possible, however, still allowing that the profit of running the ships shall be optimized.” The main elements of this policy are outlined herein.

Chapter 4 is “Propellers and Shafting for Sustainable Shipping.” The importance of the line shafting, tailshaft, propeller, and thrust shaft cannot be over-emphasised. Failure of any one of them will rend the ship inoperable with possible disastrous consequences. Single line shafting is used on the majority of ships, but not in passenger ships and on short voyage ro-ro services where twin screws are employed. Propellers, because they are outside the ship, are often neglected and are usually only inspected when the ship is in drydock. More frequent examination can be undertaken when a ship is alongside and the shafting is being rotated with the turning gear. Damage to the propeller blade can lead to vibrations being set up in the line shafting causing overheating of the shafting bearings, main thrust, etc. The selection of shafting and propeller materials is usually within manufacturers’ specifications and complies with the various classification society requirements as well as the statutory requirements of governments.

Chapter 5 is “Risk Requirement for Multi-Hybrid Renewable Energy for Marine System.” The chapter communicates environmental challenges facing the maritime industry. Efforts to integrate sources of alternative energy with existing systems through holistic proactive risk-based analysis and assessment requirements of associated environmental degradation and mitigation of greenhouse pollution are explored. The chapter also discusses alternative selection for hybridization of conventional power with compactable renewable sources like solar/hydrogen for reliable port powering.

Section 2, “Maritime Technology, Pollution, Prevention, and Protection Technology,” begins with Chapter 6, “A Point of View on How to Achieve a More Sustainable Marine Refrigerated Transport.” It is specific for our modern society to consume an important amount of food transported from one part
of the earth to another. A sustainable refrigerated transport is described by indicators like profitability, product quality, technological change, and environmental impact. Sustainable development is connected with the minimisation of irreversibilities. This is why exergy analysis is used as a powerful tool to obtain sustainable development. In this context, this chapter deals with the exergy analysis specific to the most common type of refrigerating plants on board ships. Regulations on old refrigerants, inducing technological change, are presented along with solutions for the replacement of the refrigerant R-22. The chapter also mentions the fishing industry where ammonia is the dominant refrigerant.

Chapter 7 is “Modelling of Hydrodynamics and Sediment Transport at Pantai Tok Jembal, Kuala Terengganu Mengabang Telipot, Terengganu, using MIKE 21.” This study is mainly concerned with simulation of hydrodynamics behaviours and sediment transport characteristics at coastal areas. The field data of the coastal area at Mengabang Telipot recorded by Institute of Oceanography at University of Malaysia Terengganu for January and February of year 2009 have been integrated with two-dimensional modelling system, MIKE 21. A hydrodynamic module of MIKE 21 has been used to simulate the hydrodynamic flow of the study area and the output was integrated with the non-cohesive sediment transport module to model the sediment transport patterns, capacity, and bed level changes. The effect of wave-current interaction is included in the simulation. The model simulates the hydrodynamics satisfactorily with mean current velocity 0.15 ms-1 and 0.10 ms-1, respectively, with maximum value up to 0.40 ms-1. Simulated sediment transport pattern spreads eastward predominantly and suggest an average capacity below 400 m3/yr/m. Initial rates of bed level changes vary between -0.01 m/day to 0.01 m/day. Outcome of the simulation is expected to be representative and give hydrodynamics and sediment logical information of the area.

Chapter 8 is “Evolving Sustainable Green Ship Technology.” Man lives in two worlds, the biosphere and the techno-sphere. Over the years, time needs, growth, speed, knowledge, and competition have created demand that necessitated man to build complex institutions. Ship design is not left out of this process. Inland waters are under threat from untreated waste that can feed bacteria and algae, which in turn exhaust the oxygen. The ocean, the seas, and fresh water together cover the largest percentage of planet earth. Many think that everything that runs into it is infinite; the ocean is providing the source of freshening winds and current that is far more vulnerable to polluting activities that have run off too many poisons into them. The ocean may cease to serve these purposes if care is not taking to prevent pollution. The issue of the environment has become so sensitive recently and is linked to infrastructure development work. In the maritime industry, polluting activities from oil bilge to ballast pumping has turned into poison and has an adverse effect on water resources. Some have choked too much estuarine water where fish spawn. In a nutshell, the two worlds of man are currently are out of balance and in potential conflict. Man is in the middle, and since the threats are mostly water related, ships are in the middle too. Historical records of a number of calamities that have resulted in heavy loss and pollution call for environmentally sound ships. This has led to a number of regulations that will subsequently affect policy change and procedure interaction with the system. The current situation has an effect on the design of new ships and modification of existing ships. This chapter discuss regulations design, with an emphasis on new system design drive towards processing waste and emissions on board so that discharges are acceptable. The chapter hopes to give insight into need, response, and research directions for green ship technology.

Chapter 9 is “Corrosion of Aluminium Alloy in Seawater and Development of Green Corrosion Inhibitor for Marine Applications.” Aluminium and its alloys are widely used in marine applications. Recently many studies are being carried out to use natural resources as natural corrosion inhibitors. In the present
study, the aluminium alloys were tested for their corrosion performance in seawater containing a natural product as a corrosion inhibitor at room temperature. The effect of honey on the corrosion of AA6064 was researched using the weight loss, potentiodynamic polarization, and SEM methods. Electrochemical measurements and metallurgical characteristics have been made to quantify the potential of honey to be used to retard metal corrosion. Surface morphology of aluminium coupon after exposure was examined by Scanning Electron Microscopy (SEM). A good inhibition efficiency is observed which increases with an increase in inhibitor efficiency. Polarization plots indicate that honey acts as a natural corrosion inhibitor, preventing the alloys from suffering severe pitting attacks. The weight loss results show low corrosion rates for the alloy in higher honey content.

Chapter 10 is “Modeling of Offshore Aquaculture Floating Structure for Macro Algae Oceanic Cultivation.” Seaweed farming has become one of the economically important natural resources. The existing cultivation system for seaweed is not suitable for deployment in deep and open water areas. Moreover, the current cultivation system is not environmentally sustainable and is economically unstable. This chapter describes the design of the offshore floating structures scientifically based on improvement of the Long Line System for commercialized scale seaweed farming. Some key factors in the design, prototype, and testing of floating offshore structures considered in the development of ocean farming technology systems are discussed.

Section 3, “Maritime Transportation,” begins with Chapter 11, “River Transportation Master Plan Study for Environmental Enhancement.” Inland waterways have long been utilized for various purposes including transportation. Since the development of road and rail took place, the use of inland waterways through rivers or canals has been neglected to give way for other modes of transport resulting in environmental degradation. In most developed countries, a revived plan has been formulated in implementing the optimum use of the inland waterways system for transportation purposes including USA, UK, European countries, etc. Malaysia too, owing to a substantial growth in population as well as economy, is experiencing something similar to what developed nations have gone through. With vast river network system in the country, Malaysia would surely wish to put the experiences into practice. A comprehensive master plan study should be undertaken to determine the potential rivers for development as well as to determine the level of development. The chapter highlights some considerations in ensuring the successful implementation of the environmental protection programme by developing and utilizing an environmentally friendly mode of inland water transport in Malaysia.

Chapter 12 is “A Harmonized ENC Database as a Foundation of Electronic Navigation.” The development of ship navigation classically is based on paper charts, positioning systems like sextants, or nowadays GNSS. Lead by IMO and with support by organizations like IHO and IALA, the shipping industry moves towards the future of enhanced and electronic navigation to improve safety and efficiency of ship movement around the world. The basic data layers for this development are electronic vector charts. This data layer needs to be enhanced by a growing number of other data streams to create situational awareness during any voyage, but also allow for improved planning and efficient ship movement to increase safety and reduce pollution by reducing carbon footprint and reduce risk of environmental issues due to accidents. Given that, the aim of e-Navigation is to integrate data streams, leading to information for situational awareness, which enables wise decisions for mariners on ships and support teams on shore.

Chapter 13 is “Applying the Safety and Environmental Risk and Reliability Model (SERM) for Malaysian Langat River Collision Aversion.” Collision accident remains a big threat to coastal water transportation operation. Occurrence of a collision event exposes vessel owners and operators as well as the public to risk. The nature of the threat can be worrisome; it may lead to loss of life, damage to the
environment, disruption of operation, and injuries. This makes hybrid analysis of accident frequency and consequence for risk quantification of accident scenarios through stochastic tools very imperative for reliable design and exercise of technocrat stewardship of safety and safeguard of the environmental. The study involves a predictive model for collision risk and mitigation option for aversion of collision incident. Accident frequency and consequence are obtained using probability tools. Validity of the result is checked with reliability tools. Findings of the study were checked with subsystem and uncertainty risk-contributing factors in order to arrive at a sustainable decision support for collision aversion for inland water transportation. This chapter discusses the result and validation of implementation of the Safety and Environmental Risk and Reliability Model (SERM) for aversion of collision accident for vessel navigating for inland waterways.

Chapter 14 is “A Selection of Shipping Business Strategy for Containership using an Evidential Reasoning Method.” Various shipping business strategies have been proposed by researchers due to the uncertainty of global conditions. The aims of those strategies are to reduce emissions produced by containerships and the vessel expenditure costs. A decision-making technique incorporating an evidential reasoning method, a fuzzy-link-based technique, and an analytical hierarchy process approach is used for selecting the most beneficial shipping business strategy. A set of qualitative data is obtained from expert judgments. A strategy “combination of Mega Containership and Reduction of Ports of Call” is classified as the most beneficial shipping business strategy in a dynamic operational environment.

Section 4, “Maritime Education and Training,” begins with Chapter 15 is “Using AIS Data for Navigational Risk Assessment in Restricted Waters.” The Strait of Malacca is one of the most important shipping lanes in the world. It averages 150 ship passes a day and more than 50,000 ships annually. With a high concentration of vessels in a narrow path, multiple risk situations arise. Analyzing traffic density is made harder by cross traffic and an unknown traffic density at the Strait. In 2009, Universiti Teknologi Malaysia (UTM), through a collaboration with Kobe University, successfully installed an Automatic Identification System (AIS) receiver. Through the AIS receiver, data of ship movements in the Strait of Malacca and Singapore could be recorded. A program was established by UTM to retrieve the data for the purpose of marine traffic collision risk analysis. In this research, a risk assessment method using AIS data is proposed for restricted waters such as for the Strait of Malacca and Singapore. The Risk Assessment Methodology requires the estimation of collision probabilities. The collision probability of the proposed method considers the Traffic Density, directions of traffic flow (with respect to a subject vessel), and probability of navigational failure. An area in the Strait of Singapore between the latitudes of 1°13’N and 1°07’N and Longitudes of 103°4’E and 103°56’E was selected to illustrate the method. By analysing the AIS data of traffic flow, the probabilities of collision for the area were determined. The effect of vessel parameters of length and speed on the risks of collision are also shown.

Chapter 16 is “Effect of Training on Shipboard Oil Pollution Violations.” Industrialization has brought forth comforts and catastrophes. In the regular scheme of technological developments, the worst malady faced by man is the defilement of the environment. Shipping, being a heavily regulated industry, has contributed less in comparison to other land-based polluters, but the enormity of an oil spill and the post-spill clean-ups are reasons enough for countries to tighten the pollution laws. Today, any action violating these laws is seen as a crime. Ships are being detained, penalized for pollution violations. Environmental concerns and criminalizing incidents have become issues of concern. While considering these viewpoints, a worthwhile approach would be to look at the seafarer training. Assessment of the competency of the shipboard officer is largely carried out by examinations and onboard assessments. This could be extended to other means such as research surveys. The chapter projects inputs from a study undertaken to assess the level of training and awareness in pollution matters amongst shipboard officers.
Chapter 17 is “Assessing Human Reliability Behaviour from Use of Technology for Ships Navigating within Coastal Water.” The traditional approach to the study of human factors in the maritime field involves the analysis of accidents without considering human factor reliability analysis. The main approaches being used to analyze human errors are statistical approach and probability theory approach. Another suitable approach to the study of human factors in the maritime industry is the quasi-experimental field study where variations in performance (for example attention) can be observed as a function of natural variations in performance shaping factors. This chapter analyzes result of modelling for human error and human reliability emanating from the use of technology on board ship navigation in coastal water areas by using qualitative and quantitative tools. Accident reports from marine department are used as empirical material for quantitative analysis. The literature on safety is based on common themes of accidents, the influence of human error resulting from technology usage design, accident reports from MAIB, and interventions information are used for qualitative assessment. Human reliability assessment involves analysis of accidents in waterways emanating from human-technology factors. The chapter reports enhancement requirement of the methodological issues with previous research study, monitoring, and deduces recommendations for technology modification of the human factors necessary to improve maritime safety performance. The result presented can contribute to rule making and safety management leading to the development of guidelines and standards for human reliability risk management for ships navigating within inland and coastal waters.

Chapter 18 is “Utilization of Simulation for Training Enhancement.” Engineering system design, operation, and maintenance has been handled for a long time through mathematical and real time models. The advent of computers, multimedia age, and improvement in visualization has further proved the reality of fact that picture speaks more than words; also, research in education and training has proven that visualization has a great effect on improving learning. The complexity of real world situation of engineering education has obvious limitations of instructional presentation and training. Simulation gives result from theoretical representation of complex phenomena when hardware for the task is lacking, or in situations when enough time is not available for explanation. This chapter discusses opportunities brought about by simulator as a tool in the training and certification of the Malaysian Maritime Academy cadets training program. The usefulness of simulators in a continuous education program to amplify and enhance competency-based education and instructional training to meet goals of safety, cleaner ocean, and protection of marine environment are highlighted. The chapter also presents the potential of simulators as training tools in other fields of knowledge for enhanced outcomes and competency-based education.

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