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Full Length Research Paper

Towards sustainable green ship technology

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Man live in two worlds, the biosphere and the techno sphere world over the years, time needs, growth, speed, and knowledge and competition have created demand that necessitated man to build complex institution. Ship design is not left out in this process. Inland water, are under treat from untreated waste that can feed bacteria and algae, which in turn exhaust the oxygen. The ocean cover 70% of the globe, many think that everything that run into it is infinite, the ocean is providing the source of freshening winds and current that are far more vulnerable to polluting activities that have run off into them too many poisons, that the ocean may cease to serve more purpose if care is not taking to prevent pollution. This issue of environment becomes so sensitive in recently and most are linked to infrastructure development work. Most especially in maritime industry polluting activities from oil bilge to ballast pumping that has turned into poison has advert effect on water resources. Some have choked too much estuarine water where there is fish spawn. In a nutshell, the two worlds we live are currently out of balance and in potential conflict. Man is in the middle, and since the treat are mostly water related, ship is in the middle too. Historical records of number of calamity that has resulted to heavy lost and pollution call for environmentally sound ship. This has led to a number of regulations today that will subsequently affect policies change and procedures interaction with the system. The current situation has affected the design of new ships and modification of existing ships. This paper review and discuss green technology emanating from regulations and highlight new system design being driven by marine pollution prevention and, protection and control regulation.

Key words: Sustainability, ship, design, environment, safety, mitigation, impact, control.

INTRODUCTION

Human civilization from stone age to industrial, computer, and information to multimedia innovative technological era, work has been mostly about building and forgetting the inherited biosphere environment world that support planetary life. Today human sensitivity is aggressively defining age as an age of sensitivity, safety and environment. Human developmental works for years during this era of transition have been built with oblivion or lack of consciousness to the environment. The term “environmental issues” usually implies one of two interpretations: 1) Wind, waves, tides, sediment characteristics and or other environmental factors involved in development work 2) Environmental protection in the sense of reducing the negative impact on water, air, soil quality, infrastructure, health and coastal habitat. In the first sense of the term, all concern need to agree that methods for predicting and reporting environmental conditions have greatly improved, especially in the dimension of scientific analysis. This can provide directions to connect necessary dots. In shipping and associated industries, ship protection and marine pollution are respectively interlinked in terms of safety and environment, conventionally ship safety is being dealt with as its occurrence causes environmental problem.

Pollution from maritime industry seems to be small; currently it is approximated to be 3%, especially considering green house gas (GHG) emission. Today

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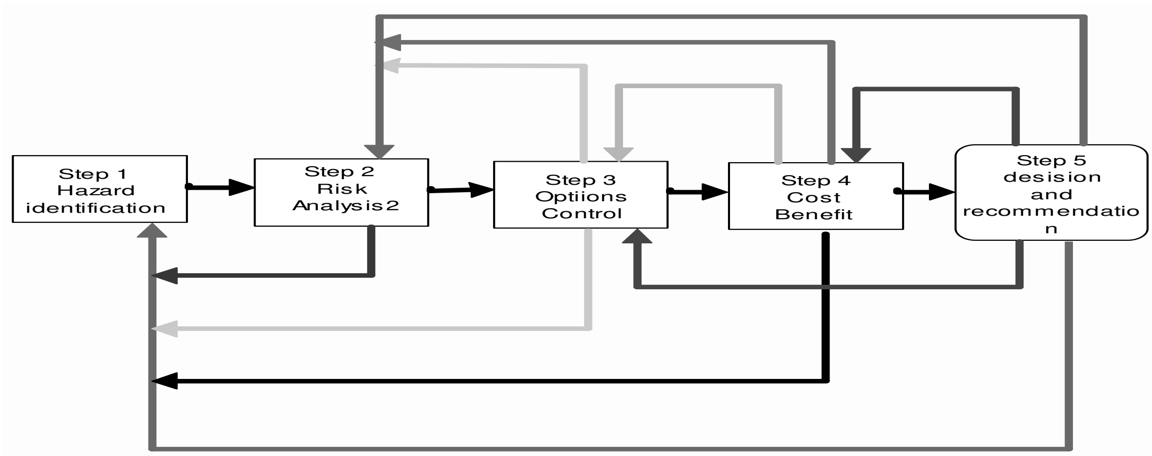

Figure 1. Risk approach.

considering volume of ships in the world ocean, pollution from shipping can be considered to be exponentially rising. Culmination of oversight regarding emission has lead to point form pollution that has contributed to the impact of ozone layer depletion, incessant flooding, global warming and more unknown calamity whose source is hard to be determined seem to be increasing if caution is not exercise in the current ways of doing things. Shipping is not left behind in this, in fact, maritime world seem to be the most to get hit by next big environmental revolt. Pollutions is about accident and accident is about pollution, because, the later is the cause of the former. This paper addresses environmental impacts to ship design with respect to human, safety, ship, reliability, channel, maneuverability factors and marine environment. The paper also emphasizes on the need to incorporate in the ship design spiral, the design process regarding the afore-mentioned enumerated factors, for example environmental issues were never part of the ship design spiral (Erik, 2009; Intertanko, 1998; NMD, 2008).

REVIEW APPROACH

This review paper collected information and used a risk based approach to analyze environmental issue, ship system, current practice and regulatory analysis to deduce prospect green technology and practice for ship. Figure 1 describes the qualitative process of examination of the issue under examination, which involve matching system requirement with regulation to deduce gap and technological requirement. The issue of green ship concept is addressed by analyzing evolving technology. In respect to the afore-mentioned, current situation is examined, policy, demand, mitigation and way to move forward green ship is addressed. Also addressed is importance of simulation and scientific system based risk analysis, especially for ship complex and dynamic system design, and channel accommodation of large ship movement in port as well as the introduction of marine environment awareness in maritime curriculum. Need to incorporate as much of cybernetic technology in navigational and maritime operations for sustainable and efficient performance is stressed. Actionable marine environment mitigation measure, recommendation for strategies to achieve safe, cost marine ship efficient navigation and protection of the marine environment cost effective state of art sustainable of ship design at planning stage is advised (Intertanko , 1998). Risk based design is advised to be incorporated in decision leading adopting new green technology, the process should include determination of high goal based objectives from gap between system compatibility with compliance couple with hazard identification, this is followed by risk analysis and risk control option, then reliability, system complexity and uncertainty analysis and lastly cost benefit, and sustainability analysis. Figure 1 shows risk approach to process for green ship technology.

Less attention is also given to ship life cycle, material properties, variable and frequency matching with the environment. A situation that has led to unbearable condition like corrosion and other unseen environmental degradation that accumulate into painful catastrophically loses or abrupt system failure. Also in the long run, ship scraping and what happen to the environment after ship scraping is another issue of environment under discussion in International Maritime Organisation (IMO). In ship recycling little or no attention is given to the residual material that finds their ways to pollute the sea (IMO, 1980; Bian et al., 2000). Other areas of concern in the ship design process are consideration for channel design criteria, ships controllability and maneuverability in dredged channels due to rapid erosion. All in all, incorporating preventive and control sensible measures in ship design can only be optimize method and give us confidence reliability on our for environment environmental conservation. Focal areas that need revolutionary changes in ship design that is being identified in this paper (Tarrason et al., 2003) include issue relating to material selection to withstand structural, weight, economical lifecycle anticorrosion and fouling, incorporating ship simulation at early stage of ship design as well as structural scantly to withstand structural function, reliability, integrity, weight and economical lifecycle. Also discussed is incorporation maneuvering ship simulation at early stage of design iteration, incorporate new close loop environmental disposal technology system to make new ships environmental safe towards achieving low pollutions and efficiency ship system.

ENVIRONMENTAL ISSUE AND IMPACT AREAS

Environmental issue becomes a blessing through opening new window of green technology opportunity for conservation, recycling, miniaturization, system integration and management of resources. It is important to start to implement clean ships initiative for ship design, this include optimal choice require to design shipboard pollution control system that will allow waste or hazard treat or process on board or allow integration of such system in existing ship. Most especially, it is necessary to incorporate such system in earlier ship design process through forming basic concept to set aside enough space on board for scalable, efficient proactive and sustainable system (Watson, 1998). There is need to design system that will allow waste to be destroyed on board the ship and those that cannot be destroyed would be treated to level where discharge is harmless. Advert environmental occurrence and impact of recent days, is evolving sensitivity leading to new policies for pollution control and more seem to be coming (WHO, 2003). For example,
NOx emission limit compliance and SOx sulfur emission control area (SECA) in the Baltic is an example of best practice that is being implemented. If actions are not taken now, the repercussion could include similitude of inconvenience of discharge regulation, possible more MARPOL special discharge areas and augmentation of confusion caused by waste signature (advert of floating of debris).

Considering the beneficent part of this contemporary issue, environmentally sound ship with self contained pollution control system, can be independent of shore facilities for shipboard waste management and will end up reducing logistic requirement and costs. Time has seen how in economical and inconvenience it is for ships pumping liquid waste to pier side reception facilities, offload solid waste and excess hazardous material for disposal. Where vessels are astronomically being charge substantial costs by private contractors to dispose generated wastes. With this, green ship will nonetheless give the following beneficial business advantages to maritime industry green ship certification (Karma and Morgan, 1975). With green ship credential, the ships will be among the significant ship of tomorrow, they will be the ship with good pride and public image that will provide leadership definition to shipping companies of tomorrow. They will be safer, environmental friendly (everything around them including marine recourses will be safe). Also, the ship will maintain good relationship with legislation and environmental agencies (hence minimizes the risk of fines and litigation). Green ship will helps in the control of operational pollution, ship movement in waterways, minimizing the risk of an environmental incident and enables companies to demonstrate a proactive approach to environmental protection. Green ship concept will also helps companies to gain recognition of investment in pollution control technology as well as improves operational efficiency will provides confidence that environmental risk is being managed effectively. High levels of environmental performance can create competitive advantage

In today environmentally conscious world, there is already so much pressure on ship owners to minimize the impact of their operations on the environment. More regulations are likely to be enforced; luckily, human civilization is enjoying an age of environmental based innovation and development. Advancement in transportation, information and technology has involved dynamic and complex activities that manage speed, safety, reliability, miniaturization, cost, mobility and networking in most industries efficiently. This poweress of human civilization is evidence that technology that is required to developed efficient low pollution and environmental friendly technology are available. It is matter of exercising more creativity and culture of sharing, complementation available resources within limited time and employing them to meet requirement of sustainable system equity law (safety, cost, speed, efficiency, low pollution etc) (Landsburg et al., 1983).

Major environmental impact areas

Environmental protection is considered a design constraint when evaluating cost, schedule, and performance of systems under development, and product improvement. The engineer need to consider the environmental impact of proposed actions, and mitigation plan required to supports unrestricted operations. This can be achieved by developing, producing, installing, and managing all shipboard equipment, systems, and procedures require reducing and managing shipboard wastes in compliance with existing and anticipated environmental worldwide restrictions. Table 1 shows Global warming potential for from marine activities. This should be done without jeopardizing the ship mission, survivability, or habitability. The major effects of ships environmental effects that must be prevented, protected or control can be in the

Table 1. Global worming potential (GWP) of various compound (RINA. 2007).

Compound	GWP (100 Year ITH)	Inclusion
Cox	1	
NOx	296	Natural occurring compounds
CHX	23	
HFC-134a	1,300	
HFC-227ea	3,500	HFC`s
HFC-c-23a	12,000	
CF	1	Novec 1230 Fire protection fluid

following form of intentional and unintentional discharge from ship (oil, garbage, antifouling paint, and transfer of indigenous species from ballast water), or environmental damage and pollution due to port activities, or disturbance of marine environmental (collision and noise) or intentional and unintentional (emission from energy equipments as well as from scraping of ships at the end of their life cycle) (IMO, 1998; Slocombe, 1993).

Risk associated with environmental issue in ship design (MSA, 1995) involve i) accidental risk: that includes marine accident that could result to that oil spills which then end up degrading the environment. Group of Expert on Scientific Aspect of Marine Environmental Protection (GESAMP) reported that 300 to 400 thousands of oil that entered the world ocean according to (GESAMP, 1993) was caused by collision with marine mammal, which then cause propeller injuries, hence more economic losses. ii) Operational risks: socio economic impacts to marine ecology, habitat, and coastal infrastructures are affected through operational activities that result to oil spill, emission, ballast water, garbage, dredge contamination, and antifouling. Other accident risk are vessel, channel and maneuverability risk: in the context of ship design, the impacts areas are related to shipping trends, channel design criteria, ship maneuverability, ship controllability, and use of simulators in channel studies. Since World War II many nations built port but forget about maintaining them according to larger ships being produced by shipyards. Physical dimension and ratio of ships to channel that have impact in today's ship controllability design include Increase in ship beam expansion where as channel width is not, length/beam (L/B) ratio; Radius of turns and turning areas-radius of turns is directly related to navigation safety and protection of the marine environment, large rudder angles are needed to navigate small radius turns rudder size, this is hardly critically taken into consideration in ship design work; Power/tonnage ratio and minimum bare steerage speed and windage;

Over the last decade, each passing years has been augmented with concerned about issue of environment. The issue touch all area of human endeavors, in maritime technology this include design, construction, operation and beneficial disposal of marine articraft. The non renewable energy source that has driven past technology has ended up with increasing the resources of the planet, but depleting components of environment that support life. This has accumulated to production that demands long term sustainability of the earth. Precipitated point form pollution effect over the year is currently calling for public awareness and it translating into impacts of the following areas described (Barry, 1993):

i) Commercial forces: this include situation of company or product that operate in unenvironmental friendly way, people are prone to spurn the company's products and service. This has impact on company return on investment.
ii) Regulations: public pressure on governmental and non-governmental organization regulating environmental impacts due to untold stories of disaster and impact. The public is very concerned about quality of life of people and the need for it is to be sustained. To meet their requirement and need of the future generation, then the environment must be protected. Conspicuous issue, expertise and new finding on multidimensional uncertainty make them to go extra length on unseen issue. Contrasting between the first two, commercial force action on can become forth problems.
iii) Water, air and soil pollution: Water volume that support the planet, scarcity of land, Global warming and health impacts.
iv) Ship concept design: is very important in shipping and it account for 80% of failure, therefore compliance and making of optimal design at concept stage has a great impact in ship whole life cycle. The impact of environment in ship design is very difficult because of large numbers of associated uncertainties within the phases of design process.

Environmental impact that need to be taken into considerations in concept design that take into consideration (IMO, 2000) construction and associated elements of pollution, this comes into picture when multidirectional thinking give wisdom on what happen during transportation, material handling and what is being released to the nearby rivers. Operations considering limiting life cycle of ships at estimate of 20 years, issues relating to operation are equally not easy to quantify in design work. Even thus a lot of research effort has been set on to move on this. But the call of the day requires allowable clearance and solution to be given to accidental, ballast waste, fouling and biodiversification. Disposal: issue of disposal that cover waste and emission and as well as what to do with the ship at the end of her life cycle. And finally energy and environment: The case of air pollution, global warming, ozone depletion and climate change.

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a) Construction: this involve pollution, this comes into picture when multidirectional thinking give wisdom on what happen during transportation, material handling and what is being released to the nearby rivers.
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c) Disposal: issue of disposal that cover waste and emission and as well as what to do with the ship at the end of her life cycle.
d) Energy and environment: The case of air pollution, global warming, ozone depletion and climate change

International Maritime Organization (IMO) gets serious

Evidence about the volume of the water planetary percentile, how significant this is to the safeguard of the planet and conversely the volume of ships that ply every day the ocean of the world put pressure from land based environmental organization to sea based regulatory governor (IMO, 2000; De Leeuw et al., 2001).

Important IMO Conventions (http://www.imo.org/About/Conventions/ListOfConventions)

i) International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended
ii) International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997(MARPOL)
iii) International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) as amended, including the 1995 and 2010 Manila Amendments.

Other conventions relating to maritime safety and security and ship/port interface

i) Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972
ii) Convention on Facilitation of International Maritime Traffic (FAL), 1965
iii) International Convention on Load Lines (LL), 1966
iv) International Convention on Maritime Search and Rescue (SAR), 1979
v) Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation (SUA), 1988, and Protocol for the Suppression of Unlawful Acts Against the Safety of Fixed Platforms located on the Continental Shelf (and the 2005 Protocols)
International Convention for Safe Containers (CSC), 1972
Convention on the International Maritime Satellite Organization (IMSO C), 1976
The Torremolinos International Convention for the Safety of Fishing Vessels (SFV), 1977
vi) International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995
Special Trade Passenger Ships Agreement (STP), 1971 and Protocol on Space Requirements for Special Trade Passenger Ships, 1973
vii) Other conventions relating to prevention of marine pollution

Table 2. MARPOL Coverage.

MARPOL (Annex)	Coverage
I	Oil
II	Noxious liquid chemicals
III	Harmful Goods (package)
III	Sewage
III	Garbage
VI	Emission and air pollution -SOx, NOx and green house gas Green House Gas (GHG), emission of ozone depletion gas (ODG)Ozone Depletion Gas (ODG)

viii) International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC), 1972 (and the 1996 London Protocol)
ix) International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990
Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)
x) International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS), 2001
International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004
The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009
xi) Conventions covering liability and compensation
xii) International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969,
1992 Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 1992)
Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material (NUCLEAR), 1971
Athens Convention relating to the Carriage of Passengers and their Luggage by Sea (PAL), 1974
Convention on Limitation of Liability for Maritime Claims (LLMC), 1976
International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), 1996 (and its 2010 Protocol)
International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001
Nairobi International Convention on the Removal of Wrecks, 2007

Other subjects convention

i) International Convention on Tonnage Measurement of Ships (TONNAGE), 1969
ii) International Convention on Salvage (SALVAGE),1989

Policies and procedures build-up: Pollution / emission prevention and control

The earlier pollution regulation by IMO work under International convention for the prevention of pollution from ships involves (MARPOL) 1973. It covers accidental and operational oil pollution as well as pollution by chemicals, goods in packaged form, sewage, and garbage. Its adoption was later modified to follow tacit procedure by protocol of 1978 relating thereto (MARPOL 1973, 1978) because of urgency of implementation, (Table 2). New annex to MARPOL have been introduced in diplomatic conference because of need of the time. Especially annex VI was quickly adopted, but allowances are given for independent adoption and implementation because of environmental geographical differences, resources availability and also because lack of enough evidence of data (IMO, 2008).

Other areas where IMO focus on are process and facilitation and system base framework like the use of formal safety assessment and International Safety Management (ISM) check list and, documentation, and provision of International safety management. Annex is the latest that is attracting more scurrility like oxide of nitrogen (NOx) limit for new design, collection of air pollution data by al ports, sulfur emission control area. Table 2 illustrates MARPOL (1973, 1978). New Annex to MARPOL covers i) control and management of ballast water to minimize transfer of harmful foreign species EMS, 2000). ii) Global prohibition of Tributyltin (TBT) in antifouling coating - phase out in 2008. iii) Control and management of emission from ship combustion machineries (Annex VI). Other areas IMO gets serious are: i) Marine environmental protection committee (MEPC), IMO technical committee forming subcommittee on specific issue to implement regulation towards necessary mitigation. ii) International Convention on oil Pollution, Response and Cooperation (OPRC), 1990: policy to combat major incidents or threats of marine pollution through port state control (PSC) to prevent mitigates or eliminates danger to the coastline from a maritime casualty. Protocol under this convention covers marine pollution by hazardous and noxious substance (HNS Protocol). ii) The IMO proposal to regulate the use of TBT-based antifouling paints. A ban on application of

TBT-based paints in 2003 and a total ban in 2008 is suggested. In anticipation of new regulations, the marine paint industry has developed alternatives to tributyltin self-polishing copolymers (TBT-SPCs). iii) IMO establishment of safety management system (SMS). and This is a part of the requirement for obtaining and maintaining ISM certification.

As a result of this, international environmental organizations are seriously encouraging all concerned parties to galvanize their community by setting up panels, collaborating with scientists and technical bodies, to encourage the use of existing scientific bodies and research centers for global observation systems. This includes the taping of the informal sources of information related to early warning as part of the solution to deal with the problem of sharing data among countries, as well using human capacity and the rapid spread of internet as a tool for information compilation, discussions and news dissemination. Some of the land and sea based regulations that have been passed are IMO (1997), Murphy (1996), Ronald (1997): i) MARPOL (1978): Cover Annex I, includes Oil, Annex II - Noxious liquid chemicals, Annex III - Harmful Goods (package), Annex IV - Sewage, Annex V - Ballast water. ii) Adoption of control and prevention measures in 2003 by IMO, as well as problems associated with the transfer of harmful aquatic organisms in ships' ballast water to address greenhouse gas emissions. iii) IMO also passed the MARPOL Annex VI during a diplomatic conference and bypassed the usual tacit procedure. Whereby Annex VI - emission and air pollution SOx, NOx and green house gas, emission of ozone depletion gas (ODG). iv) Adopt the convention in 2004 to support the International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001. The diplomatic conference also addressed the implementation of the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990. vi) Global prohibition of TBT in antifouling coating - phase out scheduled for 2008. vii) International convention on oil pollution response and cooperation (OPRC) (1990). viii) Policy to combat major accidents or threats, control to prevent, mitigate or eliminate the danger of marine pollution from the port to its coastline from a maritime casualty. ix) Protocol on the carriage of hazardous and noxious substances (HNS). x) Oil Spills Protocol: Protocol Concerning Specially Protected Areas and Wildlife (SPAW Protocol). xii) Protocol Concerning Pollution from Land-based Sources and Activities (LBS Protocol). xii) Agenda 21 debut on sustainable development.

Maritime work and regulation has always been a top down set-up, as a result of IMO seriousness on environmental issue various maritime organization follow suite, some of the development that follows IMO actions leads to classification societies to aggressively building service on environment protection, notation, and various performance indicators to get all concern committed to running an environmentally sound ships. This include Lloyds through risk assessment holistic method deduce effects and framework for clean ship the benchmark standard and DnV has equally lunched Environmental Ballast Water Management Assessment (EMBLA) database integrated project that will manage discharge of ballast water. Other institution that take beyond compliance measure include the European Union, recently the European Union has embarked on multinational project call On Board Treatment of Ballast Water (MARTOB) ballast water. Also Montreal Protocol was passed, where some 110 governments attended Parties to the Montreal Protocol, in September 1997 where several important decisions were reached, including the tightening of restrictions on several destructive chemicals. Others global organization measure include the export of hazardous waste from Organization for Economic Cooperation and Development (OECD) countries to non-OECD countries is banned under the convention; this ban entered into force in 1998 in the EU countries. Local involve Nordic tanker, where, Trim optimization by NORDEN/Green Steam and Nordic Tankers was introduced. Effort by company involves real-time analysis of bunker quality and emissions by A. P. Møller and automated engine monitoring by Man and A. P. Møller

Policies and procedures build-up for collision preventions and control measures

Although ships may spend 90 to 98% of their operational lives underway at sea speed in deep water, it is during the mandatory beginning and end of every voyage when the risk of collisions and groundings are highest. Ensuring the ability to maintain complete and positive control of a ship's movement during these segments of a voyage is absolutely vital if that risk of navigation safety and protection of the marine environment is to be reduced. According to Intertanko's (1996) on port and putting bigger and bigger ships (and more of them) into the same old channel has been going on for a long time, to mitigate collision whose occurrence lead to environmental problem. The design recommended limit for trim by the stern for a tanker is 0.015L in accordance with Regulation 13 of MARPOL (1973, 1978), Annex I. This information, which is based on tests conducted in deepwater, includes a turning circle diagram as well as tables showing time and distance to stop the vessel from full and half-speed. IMO Resolution A601 (15), which was adopted in 1987, contains recommendations for ensuring maneuvering information is available on board the ship, furthermore, The 1995 Seafarers' Training, Certification and Watch keeping STCW Code, Section A-VIII/2 part 3-1, and article 49 require the master and pilot to "exchange information regarding navigation procedures, local conditions and the ship's characteristics." Also, Marine Board study assessed the use of numerical

Table 3. Parameters demand and Impact.

Environmental parameters	Environmental Demand	Impact areas
Ship design,	Need for longer safe life cycle	New limit definition, correct material selection, Material technology, quality control of safety and environment
Construction	High worker safety standards, low energy input	Improved hull hydrodynamic,
Emission	Minimum pollution and emission, Minimum SOx, NOx and green house gas-zero discharge	Advance close loop process on board, waste recycling equipment, improve training
Scrapping	Zero harmful emission	Beneficial disposal
Operations waste,	Efficient maneuverability	Improve maneuverability

simulation technology to train mariners and concluded that while modeling accuracy is sufficient for deep-water operations; modeling requires refinement to provide the accuracy needed for shallow and restricted water operations (Kågeson, 1999; Huey, 1997).

Ship design policy build-up

In 1971, IMO adopted Resolution A.209 (VII) establishing recommendations regarding posting maneuvering regulation II-1/29.3.2 of SOLAS requires rudder movement from 35° on either side to 35° to the other side within 28 s or less. IMO approved circular MSC/Circ.389 in 1985 establish interim guidelines for estimating the maneuverability. This include rudder size and effectiveness, ability to transit at slow forward speed, propulsion and propeller characteristics, number of available engine reversals, adequate horsepower for control, extra reserve rudder angle needed to allow for ship crabbing from wind forces or moored ship suction, visibility from bridge and bridge arrangement, hull form squat (trim and sink age) characteristics and also, effect of bank forces on moorings and passing ships, air draft, emergency anchoring ability, amount of tow line leads and line access (MARPOL, 1978).

Current ship design practice

Existing design tools cannot, at least with any degree of reliability is required to be used to design a vessel and ensure that it will ensure environmental reliability and adequate maneuverability in shallow or restricted waters. Neither can it be used to satisfy demand need by clean ships. In part this is because of the extreme on-linearity of hull and propulsion characteristics under these conditions. In general, naval architects and marine engineers are to be educated and equipped with knowledge, skills, and design processes that permit continuous checking and balancing of constraints and design tradeoffs of vessel capabilities as the design progresses. The intended result of the design process is the best design given the basic requirements of speed, payload, and endurance to achieve sustainable system design. Also, ship design focus is not placed on how the channels and waterways are designed. Even more importantly, there is a general lack of understanding of the operational scenario regarding piloting of vessels in constrained waterways. Only recently has there been a real attempt to fully integrate human operational practices with vessel design. The involvement of human beings on board vessels both extends and restricts the inherent vessel maneuvering capabilities. This also complicates the necessary methodology for assuring safe and efficient operations.

Taking waste, pollution issue and restricted waterway maneuverability as an important part of ship design spiral would be a necessary step to enabling proper tradeoffs in vessel design. The reality is that maneuverability and pollution protection is still not an important consideration in ship design of many merchant ships. The result is that design decisions that can compromise environment and collision are decided in favor of other factors. Consideration for full range of ship, channel design, environment, maneuverability, technology and human factors relationships offer opportunity to achieve high efficient and safe environmental friendly sustainable marine transportation. The new challenge of environment is also a reminder for need to squeeze in more stuff in the design spiral. Table 3 shows demand and impact parameters for technological signature.

Environmental mitigation toward green technology (pollution prevention protection and control measure)

Shipboard waste and emission prevention, protection and control

Treatment and elimination -pollution prevention or pollution control (P^2C) is backbone of the thrust in achieving

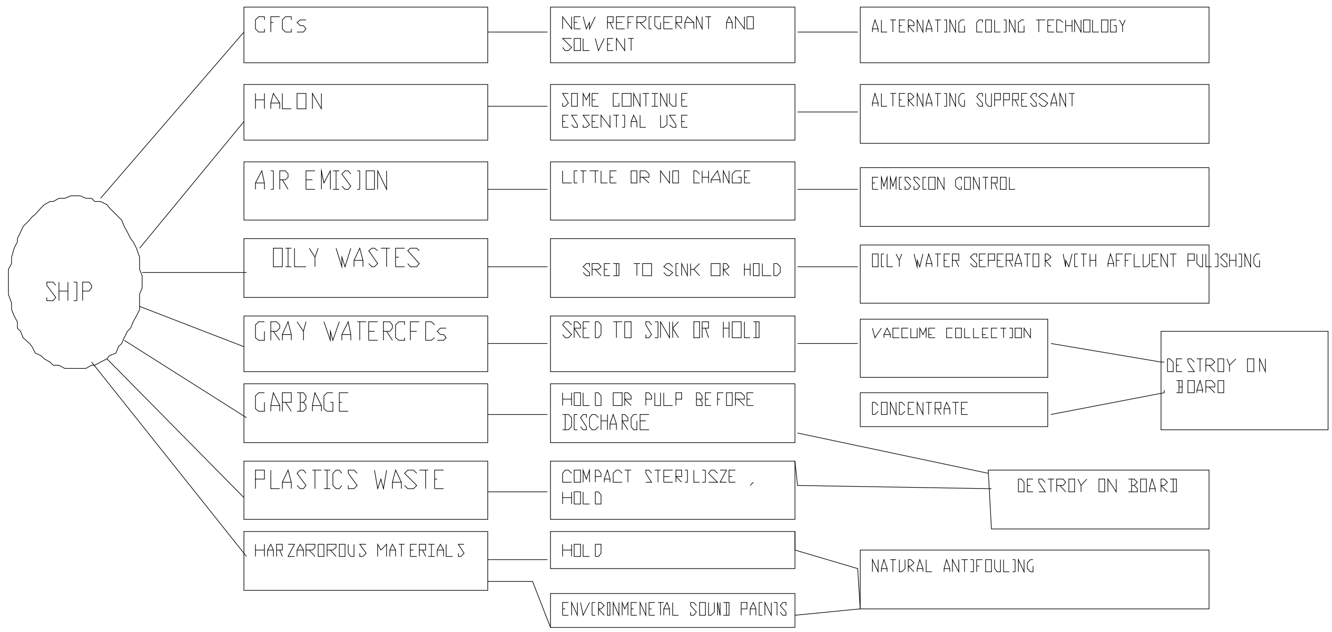


Figure 2. Strategies for green ship technology.

clean ship system and technology. Pollution prevention uses fewer environmentally harmful sub-stances and generates less waste on board. Pollution control: involve increase treatment, processing, or destruction of wastes on board. The basic of P^2C prin-ciples follows elimination of the use of environmentally harmful chemicals, such as ozone-depleting substance (ODSs), toxic antifouling hull coatings, and other hazardous materials, through the best approach for dealing with some potential problems. Reducing the amount of waste being generated on board is often better than treating it on board. For example, reducing the amount of plastics and other packaging materials taken aboard can simplify solid and plastics waste management. Similarly, reducing the volume of liquid wastes generated (such as gray water) may simplify onboard liquid-waste treatment system and ope-ration. Figure 2 shows strategies for green ship techno-logy. Table 4 shows environmental impact and response. Table 5 describes reduction potential from research conducted in Europe (NRL, 2008).

For the wastes and hazardous materials that cannot be prevented, it is important to develop pollution-control strategies and technologies categories, other technical mitigation measures are:

1) Antifouling: Toxic approach uses other metals such copper and zinc, or agrochemicals for example, triazines. Fouling release is confronted by the use physical properties of low surface energy coating that cause the very weak attachment of fouling organisms. For example, silicone based coating. Fouling deterrence marine organism not known for fouling like corals are use. Mobile hull cleaning is also being use operationally
2) Ballast water discharge: On board treatment of chemical (chlorination), physical treatment (Ultra violet light, heat treatment), filtration and cyclonic separation, shore base treatment is sometime being used but not common. Operational mitigation based on information of biological difference between coastal ocean water where ballasting and deballasting is done accordingly.
3) Air emission: Sulfur reduction in bunker fuel. Nitrogen reduction to choice of propulsion system (retrofit). On board emission control retrofitting system like, water injection, emulsion operationally speed reduction and use of shore power connection can be implemented

a) Ship to be scrap may contain on-board consumables hazardous wastes. Unless subjected to prior cleaning, these substances will follow the vessel to the ship breaking facility. Most ship dismantling occurs in developing countries. The Basel Convention controls the trans-boundary movements and disposal of hazardous wastes. Up to now dismantling sites have been chosen by ship owners on a commercial basis. This has resulted in ship dismantling activities today being mainly per-formed in a few developing countries (India, Bangladesh and Pakistan with increasing interest in China, Vietnam and the Philippines) where there is little or no alternative employment for the workforce and where safety, health and environment regulations applicable in most of the developed countries are not applied. The dismantling procedures used can result in hazardous conditions for

Table 4. Environmental impact and response (EU, 2002).

Environmental impact	Mitigation science	Mitigation response
More energy and power means more emission	Maximum fuel efficiency	environmental friendly retrofit and hybrid design, use of alternative energy
Antifouling	Harmless	Biocide free technology
Ballast water	Zero biological invasion or transfer of alien species	Segregated ballast tanks, improved ballast water tank design, ballast water treatment, ballast water data base
Sea mamma Interaction	Maneuverability capability	Safer ship structure design, Improve maneuvering capability, Navigation aid, misinformation, exchange, reeducation
Accident	Able officer, Ship structure, Integrity	New monitoring through port sate control
Fire	Harmless	Halon phase out
Wave wash of high speed marine craft	Zero inundation and spray ashore	Moderation of hydrodynamic force

the workforce and both local and global pollution of the environment. This issue concern related to ship dismantling has been raised in the UN, and the potential for improvements in ship dismantling is believed to be significant and important environmental aspects for ship at the end of their life. Methods used at present in the ship demolition industry to recover the values represented by scrap materials themselves create contamination and pollution. The discharge of gases from cutting and burn-off operations presents a threat to the environment as well as to the individuals exposed. Important environmental aspects of concern with ship breaking are Cathodic protection (Al, Zn), Batteries (Pb, Cd, Ni and sulphuric acid) Coatings and paint (PCB, Cu, Zn, Cl and TBT), Fire fighting agents, Refrigerants dichlorodifluoromethane (Freon-12), and chlorodifluormethane (R22), Thermal insulation (asbestos, PCB), The hull and large steel structures (Fe), Electrical system (Cu, PVC, PCB, Pb, Hg), m. Hydrocarbons and cargo residues.

Ship collision prevention (safety and environmental prevention, protection and control measure)

Most accident is attributed to a flagrant controllability problem. They remain the classic impetus necessary to make improvements to safety and environmental protection. There is need to ensure adequate vessel maneuverability perhaps better matching of vessel, channel, and operational practices.

1) Ship maneuverability as major iterative element of design spiral: Ship maneuverability is not considered particularly important during the design process. Because owners generally do not include maneuverability requirements as part of the design specification; Firm deep- and shallow/restricted water maneuvering standards that can be applied during the design process should be established.

2) Modeling and simulation: Collection of data using dual frequency differential global positioning system (DGPS) receivers and proper analysis needs to be supported to enable unlocking understanding of restricted water operations.

Antifouling

a) Toxic approach uses other metals such copper and zinc, or agrochemicals for example, triazines
b) Fouling release is confronted by the use physical properties of low surface energy coating that cause the very weak attachment of fouling organisms. For example, silicone based coating
c) Fouling deterrence marine organism not know for fouling like corals are use
d) Mobile hull cleaning is also being use operationally

Ballast water discharge

a) On board treatment of chemical (chlorination), physical treatment (Ultra violet light, heat treatment), filtration and cyclonic separation, shore base treatment is sometime being used but not common.
b) Operational mitigation based on information of

Table 5. Reduction potentials (NTNU, 2005).

Primary measures:	Secondary measures:	Operationally	Retrofitting for existing engines	For new engines
1.Use of low sulfur fuel – (less than 6 g/kwh) 2.HFO sulfur content - Need for oil company to change their equipment for low sulfur oil production-> ship-owner will face high cost, additive solution has been expensive so far 3. Reduction of NOx, SOx, + cost saving through boiled off gas reuse.	1. Exhaust gas cleaning system or technology Sox for SECA (Emission Control Area) & Fuel change over. 2.Nitrogen reduction through choice of propulsion system 3.Sulfur reduction -in bunker fuel 4.Reliquification plants for Liquified Natural Gas (LNG)/Liquified Petroleum Gas(LPG) carriers 5.Use of Turbo generator plant –> Paticulate matter (PM)- SAC volume is the void space in the fuel valve downstream of the closing face	1.On board Catalytic system like: Converter, water injection Emulsion 2.speed reduction (10 to 20%). 3.Use of shore power connection 4. Dual fuel option for low sulfur restricted areas (1.5-4.5), this comes with need for additional tanks. 5. The content of hydrocarbons in the exhaust gas from large diesel engines depends on the type of fuel, the engine adjustment and design.	1. Use of NOx injectors. 2.Retarding injection timing 3. Temperature control of the charge air. 4.Exhaust gas recirculation (EGR) 5.Fuel / water emulsion 6.Water injection 7.Humid air motor (HAM) technique- addition of wet steam to the engine 50% reduction 8.Selective catalytic reduction (SCR)	1.Engine certification 2.Pre-certification, 3.Technical file clarification on engine family and group, 4.Final certification 5.Alfa Lubricator system 6.Reduction in cylinder oil consumption-> reduction in particulate emission 7.Electronic control engine Programmed fuel injection for exhaust valve emission reduction 8. Use of high efficiency air flow for power take off reduces fuel and reduction of emission.

biological difference between coastal ocean water where ballasting and deballasting is done accordingly.

Air emission

a) Sulfur reduction in bunker fuel
b) Nitrogen reduction to choice of propulsion system (retrofit)
c) On board emission control retrofitting system like, water injection, emulsion
d) Operationally speed reduction and use of shore power connection can be implemented

Ship to be scrap may contain on-board consumables may hazardous wastes

Unless subjected to prior cleaning, these substances will follow the vessel to the ship breaking facility. Most ship dismantling occurs in developing countries. The Basel Convention controls the transboundary movements and disposal of hazardous wastes. Up to now dismantling sites have been chosen by ship owners on a commercial basis. This has resulted in ship dismantling activities today being mainly performed in a few developing countries (India, Bangladesh and Pakistan with increasing interest in China, Vietnam and the Philippines) where there is little or no alternative employment for the workforce and where safety, health and

Table 6. Development coalition control services model (Pedersen, 1992).

Model	Environmental performance
Kutsuro Kijima	Showed a modeling approach that permitted analysis of passing situations of vessels in waterways that would help set procedural standards for safe passing vessels in port.
IanDand	Reported on the development of models for ship squat model those have shown very good accuracy over the years.
Larry Daggett	Described the advent of dual frequency DGPS receivers and their role in gathering full-scale ship trial data. In addition to the excellent horizontal accuracy of the normal DGPS receiver, these receivers provide vertical location with an accuracy measured in centimeters.

environment regulations applicable in most of the developed countries are not applied.

The dismantling procedures used can result in hazardous conditions for the workforce and both local and global pollution of the environment. This issue concern that is related to ship dismantling has been raised in the UN, and the potential for improvements in ship dismantling is believed to be significant. Important environmental aspects for ship at the end of their life. Methods used at present in the ship demolition industry to recover the values represented by scrap materials themselves create contamination and pollution. The discharge of gases from cutting and burn-off operations presents a threat to the environment as well as to the individuals exposed. Important environmental aspects of concern with ship breaking are:

a) Cathodic protection (Al, Zn)
b) Batteries (Pb, Cd, Ni and sulphuric acid)
c) Coatings and paint (PCB, Cu, Zn, Cl and TBT)
d) Fire fighting agents
e) Refrigerants dichlorodifluoromethane (Freon-12), and chlorodifluormethane (R22)
f) Thermal insulation (asbestos, PCB)
g) The hull and large steel structures (Fe)
h) Electrical system (Cu, PVC, PCB, Pb, Hg)
i) Hydrocarbons and cargo residues

MAJOR FINDING AND BEST PRACTICE GREEN SHIP TECHNOLOGY

Environmental technology also becomes a serious issue of environment represent start of another revolution in human history. Today environmental technology product and services are booming. The major environmental aspects related to maintaining machinery and auxiliary systems are oil (additives), coolants, gases, electrical/ electronic waste, seals, insulation, and scrap-metals. The maintenance system shall design targets strategies that provide continuous improvement of existing procedures and routines. Improvements in maintenance are mainly motivated by cost reduction, and increased operational reliability and safety conside-rations, but often have positive environmental conse-quence in addition. Table 5, 6 and 7 shows some resent environmental performance products. A number of promising developments that exist today are shown in Figures 3 and 4. For green ship project, conventional wastes and emissions must be control according to the present strategy for treating or eliminating these wastes using the aforementioned principle behavior of system (Pedersen et al., 1992).

Green house emission green technology

Recent critical environmental revolt such as the issue of the rising sea levels and floods has brought about a sense of awareness with regards to environmental degradation. There is an increased awareness that everything on this planet is interconnected. Water will flow to the rivers through the ground and eventually end up in the sea. This makes the management of the quality of water and air, the balance of their purity and the prevention of the substance running into them a crucial point in protecting the environment from further deterioration (IMO, 2000). High pressure associated with air pollution due to the rapid climate change, led IMO diplomatic conferences to the new Annex VI, Chapter III which deals with the requirements for the control of emissions from ships including (IMO, 2000):

i) Regulation 12: Ozone depletion substances
ii) Regulation 13: NOx
iii) Regulation 14: SOx
iv) Regulation 15: Volatile organic compounds
v) Regulation 16: Shipboard incinerator
vi) Regulation 17: Reception facilities
vii) Regulation 18: Fuel oil requirement
viii) Regulation 19: Requirement for platform and drilling rigs.

Table 7. Environmental performance technology (NREL, 2008).

Product	Target	Environmental performance
200-Ton air-conditioning plant conversion kit	Ozone safe substances:	The CG-47and DDG-51 plants have been successfully converted to the ozone-friendly refrigerant HFC-236fa where conversion kit has been established by Naval Surface Warfare Center, Carderock Division (NSWCCD).
Waste pulpers	Solid waste: Solid	The pulper is the machine into which you dump tremendous quantities of paper, cardboard, or food waste. The waste mixes with seawater to form slurry, which is then discharged overboard. Studies show an immediate 100,000-to-1 dilution when discharged into the wake of a ship. Ships equipped with a pulper can dispose of their paper, cardboard, and food waste just about anywhere and at anytime at sea including MARPOL areas.
OWS oil water separator (OWS) and Bilge water Polishers	Liquid waste	These bilge cleaners the US Navy uses, it contain long-lasting emulsifying agents, which produce stable oil-in-water emulsions that shipboard OWSs cannot effectively process.
Valve gauge		Valve gauge assembly developed by NSWCCD the ring-gauge isolator to improve the reliability of sanitary waste system sewage transfer-pump suction and discharge gauges [8]. Figure 2 shows the valve gauge assembly.
Integrated liquid discharge system	Therma destruction	NRL plan for concept where ultrafiltration membrane systems would concentrate bilgewater, graywater, and sewage (as previously described); the clean effluents would be discharged; and the concentrates would be evaporated/incinerated in a thermal-destruction system (Figure 3)

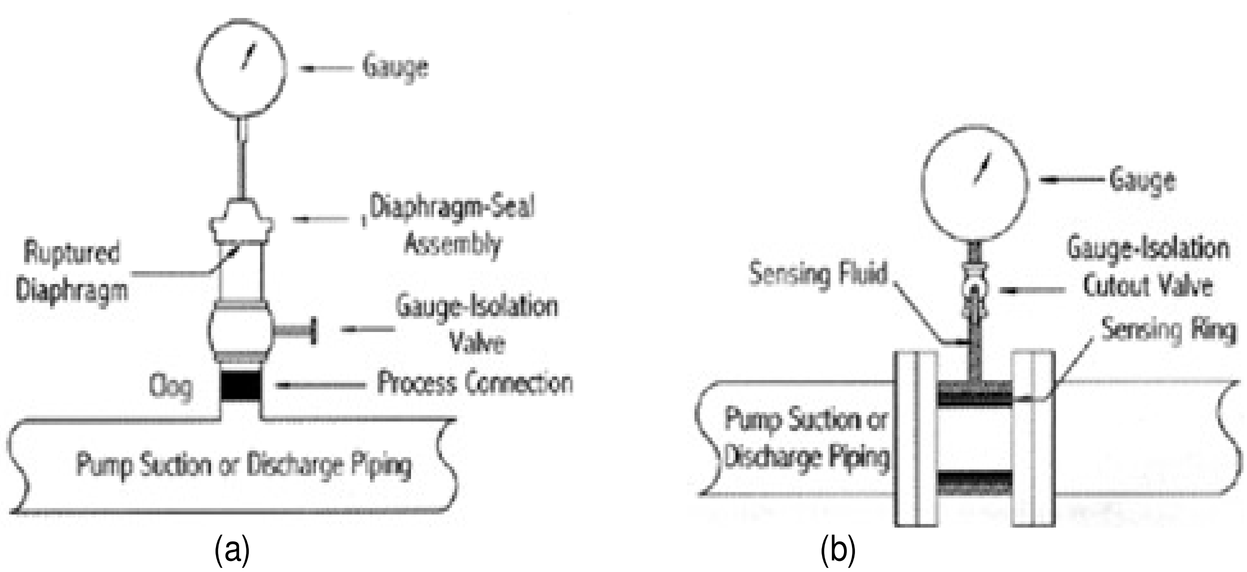


Figure 3. (a) diaphragm assembly valve assemble (b) Ring gauge valve isolator assembly (NSWCCD, 2008).

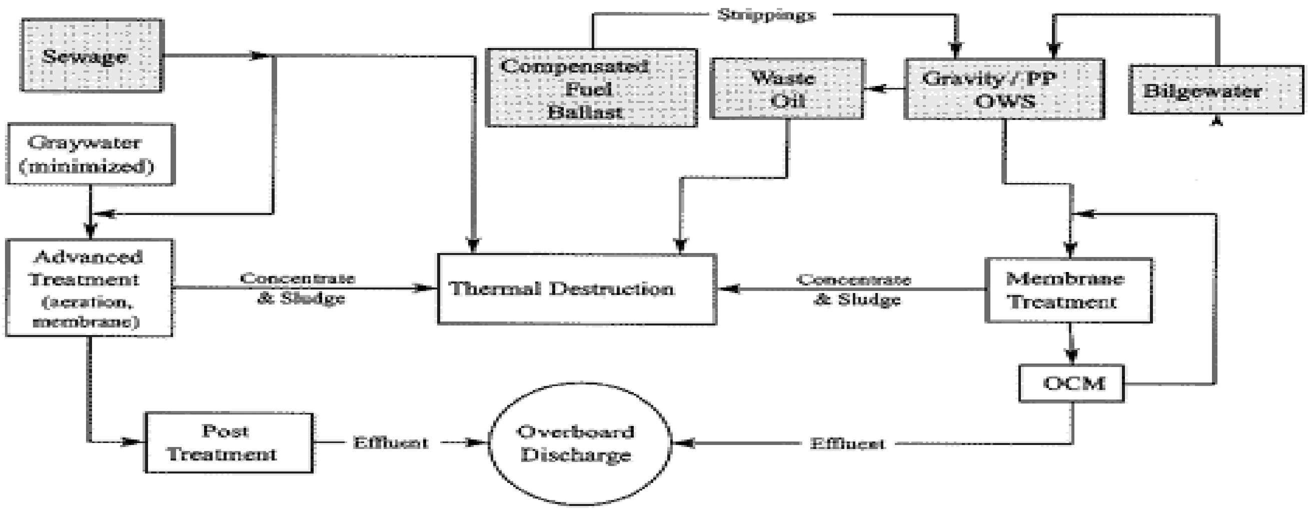


Figure 4. Integrated liquid discharge system concept (NREL, 2008).

Table 8. Emission and reduction measures (NTNU, 2007).

Category	Components	Sources	Current method of reduction
Emission to air	COx	Machineries/incinerator/boiler	Operational and energy efficiency measures
	SOx	Machineries/incinerator/boiler	Low sulfur fuel exhaust washing
	NOx	Machineries/incinerator/boiler	Exhaust cleaning, engine modification, or input media
	HC	Machineries/incinerator/boiler	Exhaust gas recirculation
	Noise	Machineries/cargo operations	Insulation
	Particles	Machineries/incinerator/boiler	Electronics lubrication and injection
	HFC/Halon	Fire extinguisher / refrigeration system	vapor return, recovery plant
	VOC	Cargo operation	Sequential loading

Fossil fuel is considered as the single largest contributor to emissions. Apart from the NOx and SOx regulation which has been introduced, COx smoke emission is likely to be regulated. To facilitate the adoption to emission regulations, operators, officers, engine builders, yards and ship-owners are doubling their efforts to adopt new technologies to make this earth a better place to live in. However of late, the issue became increasingly serious with the Marine Environment Protection Committee (MEPC) in its 60th session on 22 to 26 March, 2010 concluding that more work needs to be done before it could finalized the proposed mandatory application of technical and operational measures which was designed to regulate and reduce the emission of greenhouse gases (GHGs) from international shipping. IMO has been waiting for the outcome of the COP 15 before they hit the industry with the new emission regulations where unilateral options for the maritime industry were being considered. The technical and operational measures which was adopted includes the interim guideline on the methods of calculation and the voluntary verification of the Energy Efficiency Design Index (EEDI) for new ships, which will stimulate innovation and the technical development of all the elements influencing the energy efficiency of a ship, as well as the guidance on the development of a Ship Energy Efficiency Management Plan for all ships in operation. Table 8 shows potential achieve-ment to implementation of the technology (IMO, 1997; Psaraftis, 2009).

The main area to meet emission reduction targets, Machinery WHR, scrubbers, EGR, etc.

i) Propulsion: Propellers, rudders, trim optimization, etc.
ii) Operations: Route planning, performance monitoring, etc.
iii) Logistics: Better interaction between transport forms, envelopment development /modification of existing ship types etc.

Tables 8 and 9 show strategies to reduce air pollution from ship. In respect to operations, companies have used

Table 9. Machineries.

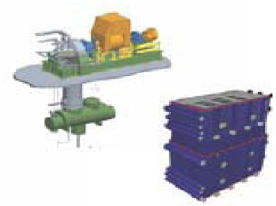
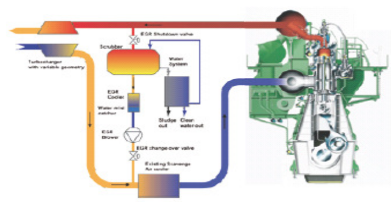
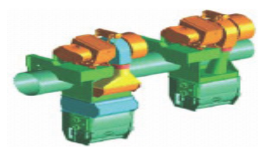
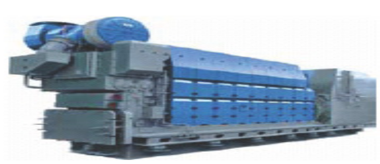
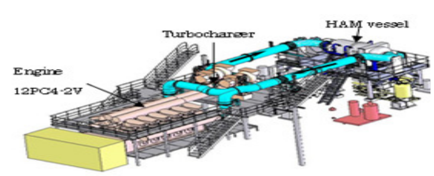
Waste heat recovery system	A. P. Møller – MAN, Aalborg Industries, Odense Lindø Shipyard		6. Use main engine exhaust gas heat that contains hot energy that is transformed to steam. The steam can be used for cargo and fuel heating power generation - 7-14% of fuel can be saved from heat recovery system (Hinrich, 2004)
Exhaust Gas Recirculation system	MAN, A.P. Møller		NOx is formed at high temperature; therefore, its formulation can be reduced by lowering the temperature in the system. Exhaust gas can be recirculated, where some is mixed scavenge air to reduce the oxygen content, and consequential reduction in temperature in the system. The technology has potential to reduce Nox by 80%.
Water in fuel emulsion (WIF)	MAN and A. P. Møller		Reduction of 30 to 35% NOx can be achieved by adding water to the fuel before injection
Scrubbers	Aalborg Industries and DFDS		This technology can be used to control future regulation of SOx release. The scrubber use water to wash the sulfur out of the exhaust gas. Testing of the system has shown SOx reduction of 98% and simultaneous reduction of harmful particle late matter are reduced by 80%.
Optimization of pump system and cooling systems	DESMI, APV, Odense Lindø, Grontmij Carl-Bro		20% electrical power generation reduction can be achieved by using optimized cooling water system. Also 90% power saving, can be achieved can be reduced through reduction in pump resistance. Pump size can also be reduced via this technology
LNG for aux. engines and gas turbines	Mols-Linen and DTU		Most diesel engine in harbor run in diesel, by using switching to LNG to run auxiliary engine under fuel arrangement, 20% of Cox35% of NOx can be achieved
Selective Catalytic Reduction	Dansk Teknologi and Danish Navy		
Turbo charging with variable nozzles	MAN and ABB		

Figure 5. Maersk line.

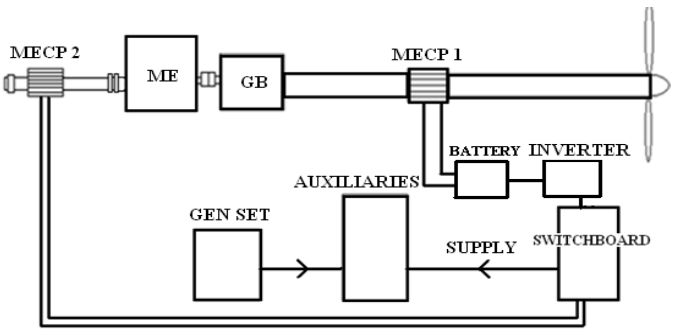
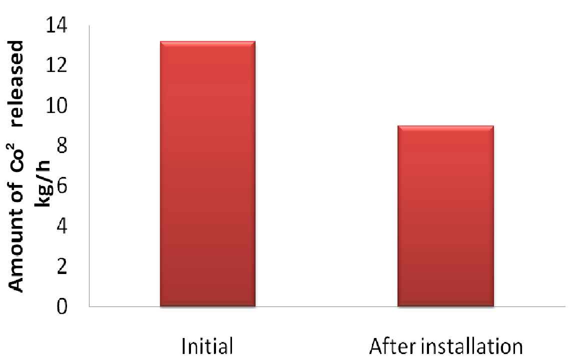
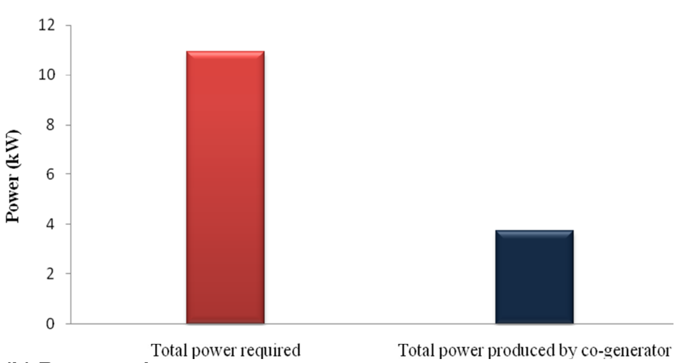


Figure 6. Magneto electric system model (UMT, 2010).



(a) Carbon capture



(b) Recovered power

Figure 7. Magneto electric model result (UMT, 2010).

voyage planning, •marine Institution established student forum that focus on green ship technologies, other arrangement at sea include introduction of 'Green shipping' in the working procedures onboard and implementation of constant focus on energy saving possibilities on the ships. In respect to logistics better transport planning, better tools for evaluation of the most, energy efficient transport forms and better cooperation between the transport providers are current practice that are working to reduce pollution (Murphy, 1996).

i) Another best practice is the case of MASRK ship a 8500 TEU container vessel, optimised with (Figure 5) waste heat recovery exhaust boilers, power and steam turbine technology
ii) Water in fuel technology (WIF), exhaust gas recycling (EGR), exhaust gas scrubber extra costs 30 mill USD (approx 10% of new building costs).
iii) Waste heat recovery exhaust boilers
iv) Power and steam turbine technology
v) Water in fuel technology (WIF)
vi) Exhaust gas recycling (EGR)
vii) Exhaust gas scrubber extra costs 30 mill USD (approx 10% of new building costs)

The goals were to have -30% reductions of CO2 emissions, achieved result include 11 to 14 to 90% reduction of NOx emissions-achieved 80 to 90% reduction of SOx emissions-achieved 90%. Figure 6 shows a magto-electric waste energy recovery system modeled numerically at UMT, while Figure 7 shows the amount of additional energy which can be produced from the system (Sulaiman, 2009).

The system offers flexibility in optimizing plant operations to minimize operation costs or maximize propulsion power. The use of these sets is considerably reduced thereby providing a further potential to reduce operating costs.

Regulatory prediction process

Figure 1 shows risk based process for system regulatory requirement. However, based on risk analysis outcome, regulation influence can be predicted and quantified by assigning a numerical weighting value to each link between factors. Future system will require design based on risk that matches system functionality with requirement. The ship design spiral shown in Figure 8 does not include most of the process described earlier, and some will require mandatory insertion in the spiral. Figure 9 show expected regulatory compliance for standards acceptability IMO model. Figure 10 shows cost benefit analyses that can be deduced from potential consequence in risk of do nothing.

In estimation of regulation, the concordant process require expert rating which is translated into the weighing factors, this weighting can be placed on factors at a lower

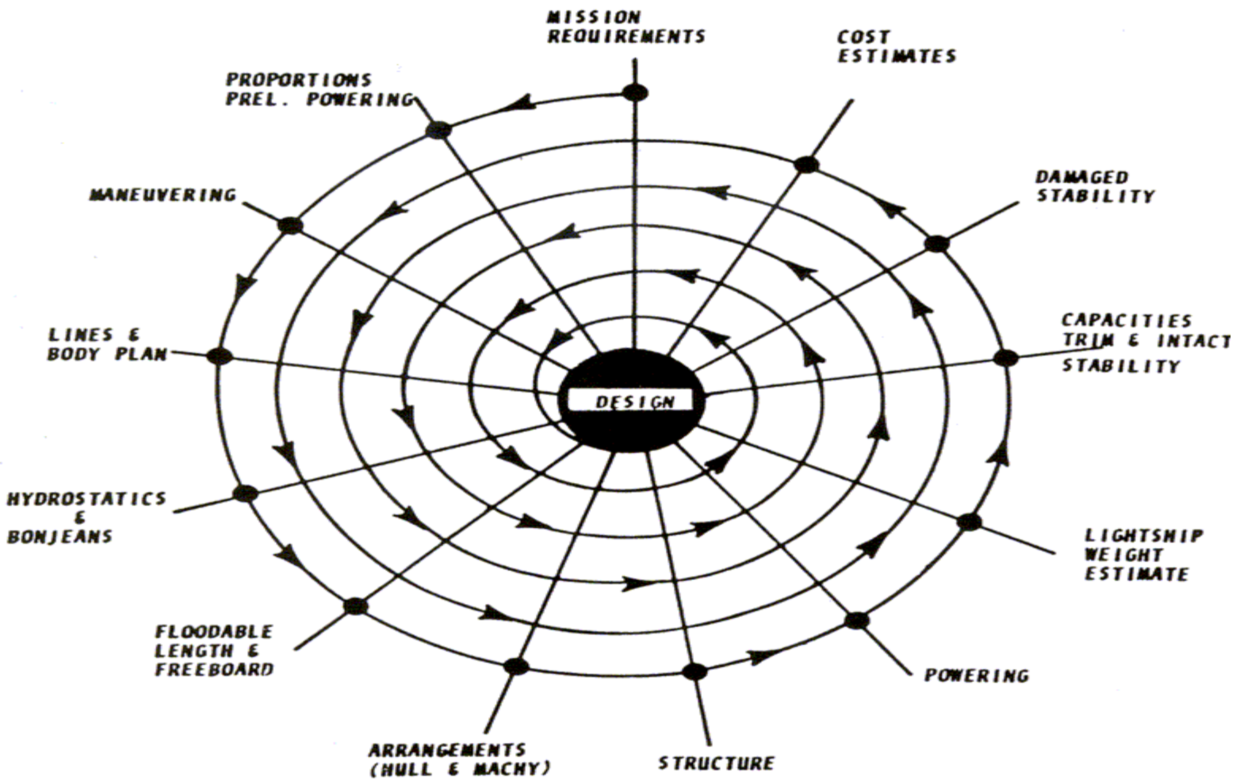


Figure 8. Ship design spiral (NRL, 2008).

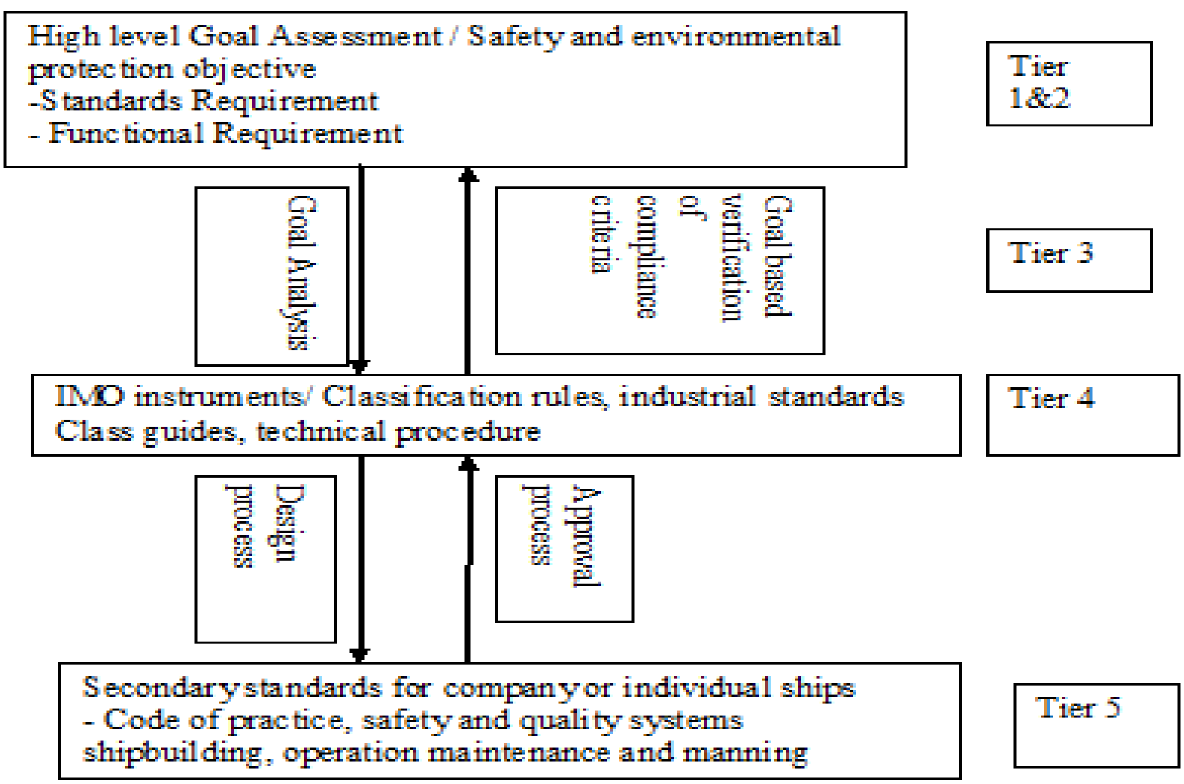


Figure 9. High Level goal standard assessment.

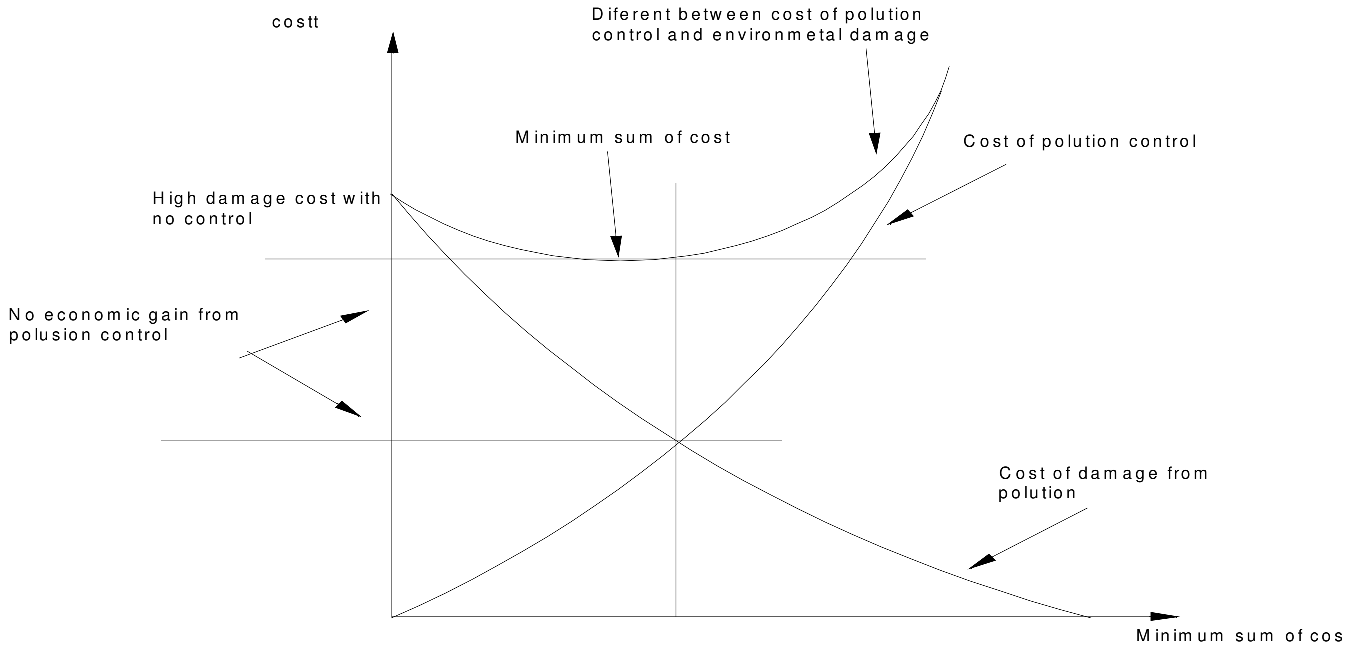


Figure 10. Cost and sustainability components.

level in the diagram, factors at a higher level that are influenced by that lower level factor, and also by assigning a numerical "rating" value to every factor. The weighting values between factors quantify the relative importance of the influence of lower level factors upon higher level factors. Weighting values are assigned as percentages on a scale of zero to 100%, such that for any factor at a higher level, the sum of the weightings of all the lower level factors which influence the higher level factor is 100%. This is otherwise described as Concordia principle.

$$W1 + W2 + W3 + W4 = 100\% \quad (1)$$

Where W1, W2, W3, & W4 are the weightings linking factor E1, E2, E3, & E4 to factor P1. Consider the environmental level factors which link with the first policy level factor, P1. Say these environmental level factors are E1, E2 and E4. Let the weightings of these environmental factors on the first policy level factor be W (E1, P1), W (E2, P1) and W (E4, P1) respectively. Furthermore, let the respective ratings of these factors be R (E1), R (E2) and R (E4. W (E1, P1) W (E3, P1) W (E2, P1). A calculated rating value for factor P1 is derived as being: Figure 8 shows the regulatory requirement to achieve design goal.

$$R(P1c) = R(E1) \times W(E1,P1) + R(E2) \times W(E2,P1) + R(E4) \times W(E4,P1) \quad (2)$$

Figure 10 shows cost and sustainability analyses instrument graph. The way forward

Recent safety and environmental strategic focus on developing metrics to measure and evaluate progress, the key to issues and actions are is to be incorporated in the clean ship concept. Ships owner and operators must understand the need to include wastes stream management in mission requirement in the design stages, with the goal of ships being in compliance. Ship designer must pursue technologies to reduce or eliminate waste streams. The metrics use to monitor progress towards achieving environmentally sound ships will focus on shipboard pollution control equipment installations, specifically the planned versus actual installations. Each waste stream or environmental pollutant, equipment installations, the percentage of total installations completed versus the planned percentage, will be used as a measure of progress for that waste stream. For waste streams and contaminants for which no equipment has been approved or anticipated, the metric will born many R&D for necessary findings. There is need for effectively integration of pollution prevention and safety into the design and life cycle of our ships, systems, ordnance into the execution of our processes, and into the operation. Managing the whole process is another thing; environmental management can be optimizing by incorporating the following concept in our system. Table 10 shows potential marine technology research are for waterborne transportation, this include Total cost minimization concept, innovative safety and environmental strategy management and integration planning for uncertainty and risk, use of probabilistic and holistic methods, education

Table 10. Propulsion.

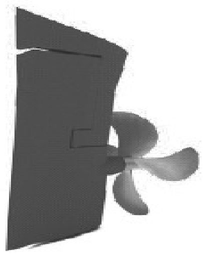
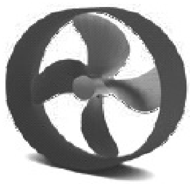
New paint systems	Hempel		Choosing right antifouling paint with low water friction is beneficial to reduce ship resistance and subsequencial saving of fuel of 3 to 8%, hence proportional reduction of emission.
Advance Rudder and propeller system	MAN and ABB		Modern ruder design that combine propeller with asymmetric ruder called costa bulb, efficient propeller design provide smooth slipstream from the proper to the rudder, and asymmetry rudder rotational energy is utilized more efficiently.
Speed nozzle	MAN and ABB		Nozzle are used to improve the bollard pull on tugs, supply vessel, fishing boats and other vessel which need high pulling power at low speed. Speed nozzle are modern nozzle with improve propulsion power at service speed. The technology has reduction capability up to 5%

Table 11. Marin technology and research areas for waterborne transportation.

Marine technology areas	Need	Technology platforms
Efficient, safe and environmentally friendly ships and vessels of the future	Improvement of concepts of multi-site design, engineering or environmental kindliness production	fast vessels for passengers, cars and cargo; - deep-sea ships for passengers and unit cargo; - deep-sea floating structures for production storage and off-loading of gas; - unmanned, autonomous and remotely operated survey vehicles; and - new concepts for short-sea operations and polar shipping.
Maximizing interoperability, transshipment and vessel performance	Improvement of port infrastructures, reducing operating costs, improving maneuverability of ships in restricted waters and ports and efficient cargo handling and transshipment.	Research is focusing on integrating advanced concepts for unitised cargo and for ship types operating in coastal, restricted and limited waters. The strategic aim is to demonstrate concepts for multimodal cargo units and reinforcing intermodal links to ease improve and facilitate cargo flows between inland waterways and the sea.
Innovative technologies for monitoring, exploration and sustainable exploitation of the sea	Development unmanned surveying, in-situ monitoring and industrial operation.	
Competitive shipbuilding	Hull design to reduce environmental impact from loss of structural integrity, fuel consumption through hull form optimization, wave / wash generation, corrosion noise and vibration and use of new material.	Research is helping to demonstrate streamlined and seamless vessel development processes and systems, and support advanced production systems which improve customer response, product quality and manufacturing process flexibility and control

and training.

CONCLUSION

Working better by working together

This paper discussed environmental technology issue and potential research direction for green technology for ship. Beside miniaturization, use of nature and system integration will be next in line in the process for system to work efficiently. Even thus, the environment has naturally integrated everything in this planet between air, water and soil. The same apply to maritime industry on the issue of safety and marine environmental impact control and protection. Environmental issue has become so sensitive because it is more or less of evidence that nature has exercise enough patience, impact has reach flash point and those who are knowledgeable about the behavior of matter and environment have been giving predictive data about potential of contagious chain reaction of climate change and potential consequential heavy calamity damage and lost. Existing engine and future engines will be forced to adapt new technologies presented in this paper in the near future. Green technology highlighted in this paper will be a major catalyst to ignite a series of research activities to solve the current energy and environmental problems. Data collected from such research will be utilized to enforce relevant climate change control and compliance laws. The data can be used for simulation purposes and support the deployment of new systems. The evolving technology discussed could help meet the current demand by IMO for the implementation of Energy Efficiency Design Index (EEDI), Ship Energy Efficient Management Plan (SEEMP) and Ship Energy Efficiency Operational Indicator (SEEOI) rules which was launched recently towards global warming, climate change and ozone depletion in the maritime industry. The following are recommended for future technological compliance to regulation:

1. It is important for the main players in marine time industry (pilots, regulators, channel designers, simulator experts and ship operators) to share experience regarding differences in rules and design requirement for clean system.
2. Among regulators it is important to review rules that are taken too light, most of which are currently being implemented unilaterally because of variability in environment.
3. Naval architects and ship handlers alike should take the importance of GHG, green ship issue, risk based design and ship maneuvering unrestricted in ship design process. It is important o integrate design requirement related to this in ship design spiral.
4. Tackling the issue of environment equally required hybridizations of all the methodology we have been using reactive process. The use of proactive approach that consider sensitivity of area, degrees of hazard for various ship types, and of course employment holistic institutionalized risk based system design method that compare and consider trend analysis of every elements of the new sustainable technology system development is recommended.

The political will for green technology is a wakeup call for all ship owners to be ready for new regulatory regime that will dictate technology for ship. Green ship technology will also be main factors for shipper and ship charters and insurance company look looking for in order to make decision for future business deal. Adoption of green ship technology will define significant ship, award winning vessel and qualification of green passport of next generation ship. That ship will be able to go anywhere and will face no delay in their transportation activities.

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Appendix. IMO Conventions.

1. Convention on the International Maritime Organization (IMO CONVENTION) (in force);
2. 1991 Amendments to the IMO Convention which were adopted by the Assembly of the Organization on 7 November 1991 by resolution A.724 (17) (IMO AMENDS -91) (in force);
3. 1993 Amendments to the IMO Convention which were adopted by the Assembly of the Organization on 4 November 1993 by resolution A.735 (18) (IMO AMENDS-93) (in force);
4. International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS 1974) (in force);
5. Protocol of 1978 relating to the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS PROT 1978) (in force);
6. Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974 (SOLAS PROT 1988) (in force);
7. Agreement concerning specific stability requirements for Ro-Ro passenger ships undertaking regular scheduled international voyages between or to or from designated ports in North West Europe and the Baltic Sea (SOLAS AGR 1996) (in force);
8. Convention on the International Regulations for Preventing Collisions at Sea, 1972, as amended (COLREG 1972) (in force);
9. Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973, as amended (MARPOL 73/78)
10. Annex III to MARPOL 73/78 (in force);
11. Annex IV to MARPOL 73/78 (in force);
12. Annex V to MARPOL 73/78 (in force);
13. Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL PROT 1997) (in force);
14. Convention on Facilitation of International Maritime Traffic, 1965, as amended (FAL, 1965) (in force);
15. International Convention on Load Lines, 1966 (LL 1966) (in force);
16. Protocol of 1988 relating to the International Convention on Load Lines, 1966 (LL PROT 1988) (in force);
17. International Convention on Tonnage Measurement of Ships, 1969 (TONNAGE 1969) (in force);
18. International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969 (INTERVENTION 1969) (in force);
19. Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil, 1973, as amended (INTERVENTION PROT 1973) (in force);
20. International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC 1969) (in force);
21. Protocol to the International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC PROT 1976) (in force);
22. Protocol of 1992 to amend the International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC PROT 1992) (in force);
23. Special Trade Passenger Ships Agreement, 1971 (STP 1971) (in force);
24. Protocol on Space Requirements for Special Trade Passenger Ships, 1973 (SPACE STP 1973) (in force);
25. Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, 1971 (NUCLEAR 1971) (in force);
26. Protocol of 1992 to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (FUND PROT 1992) (in force);
27. Protocol of 2000 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1972 (FUND PROT 2000) (in force);
28. Protocol of 2003 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992 (FUND PROT 2003) (in force);
29. International Convention for Safe Containers (CSC), 1972, as amended (CSC 1972) (in force);
30. Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (PAL 1974) (in force);
31. Protocol to the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (PAL PROT 1976) (in force);
32. Protocol of 1990 to amend the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (PAL PROT 1990) (not yet in force);
33. Protocol of 2002 to the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (PAL PROT 2002) (not yet in force);
34. Convention on the International Mobile Satellite Organization (Inmarsat), as amended (INMARSAT C) (in force);
35. Operating Agreement on the International Mobile Satellite Organization (Inmarsat), as amended (INMARSAT OA) (in force);
36. Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC 1976) (in force);
37. Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC PROT 1996) (in force);
38. International Convention on Standards of Training, Certification and Watch-keeping for Seafarers, 1978, as amended (STCW 1978) (in force);
39. International Convention on Standards of Training, Certification and Watch-keeping for Fishing Vessel Personnel, 1995 (STCW-F 1995) (not yet in force);
40. International Convention on Maritime Search and Rescue, 1979 (SAR 1979) (in force);
41. Convention for the Suppression of Unlawful Acts

against the Safety of Maritime Navigation (SUA) (in force);
42. Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms Located on the Continental Shelf (SUA PROT) (in force);
43. Protocol of 2005 to the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA 2005) (not yet in force);
44. Protocol of 2005 to the Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms Located on the Continental Shelf (SUA PROT 2005) (not yet in force);
45. The International COSPAS-SARSAT Programme Agreement (COS-SAR 1988) (in force);
46. International Convention on Salvage, 1989 (SALVAGE 1989) (in force);
47. International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC 1990) (in force);
48. Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS 2000) (in force);
49. Torremolinos Protocol of 1993 relating to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (SFV PROT 1993) (not yet in force);
50. International Convention on Liability and Compensation for Damage in connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996 (HNS 1996) (not yet in force);
51. International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 (BUNKERS 2001) (in force);
52. International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001 (AFS 2001) (in force);
53. International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM 2004) (not yet in force);
54. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, as amended (LC 1972) (in force);
55. 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (LC PROT 1996) (in force);
56. Nairobi International Convention on the Removal of Wrecks, 2007 (NAIROBI WRC 2007) (not yet in force).

Instruments which are in force or applicable but which are no longer fully operational because they have been superseded by later instruments[1]

1. International Convention for the Safety of Life at Sea, 1948 (SOLAS 1948)
2. International Convention for the Prevention of Pollution of the Sea by Oil, 1954, as amended (OILPOL 1954)
3. International Convention for the Safety of Life at Sea, 1960 (SOLAS 1960)
4. International Regulations for Preventing Collisions at Sea, 1960 (COLREG 1960)
5. International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (FUND 1971)
6. Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (FUND PROT 1976).

Instruments not yet in force and not intended to enter into force

1. International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL 1973)
2. Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (SFV 1977)
3. Protocol of 1984 to amend the International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC PROT 1984)
4. Protocol of 1984 to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (FUND PROT 1984).