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Knowledge-Humility-Excellence

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IIRE Journal of Maritime Research and Development

Maritime sector has always been influencing the global economy. Shipping facilitates the bulk transportation of raw material, oil and gas products, food and manufactured goods across international borders. Shipping is truly global in nature and it can easily be said that without shipping, the intercontinental trade of commodities would come to a standstill.

Recognizing the importance of research in various aspects of maritime and logistic sector, IIRE through its Journal of Maritime Research and Development (IJMRD) encourages research work and provides a platform for publication of articles, manuscripts, technical notes, papers, *etc.* on a wide range of relevant topics listed below:

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Editorial

This issue has papers focusing on some very contemporary areas of developments in the shipping industry.

Regulation 14.1.3 of MARPOL Annex VI stipulates that the sulphur content of any fuel oil used on board ships must not exceed 0.50% m/m from 1 January 2020, except for ships using 'equivalent' compliance mechanisms. The 'equivalent' compliance mechanisms permitted by Annex VI, Regulation 4, include LNG or exhaust gas cleaning systems. Dr Vivek Jain makes a lucid presentation of compliance alternations. Of course the caveat remains - while the technological solutions are many, decisions are hard to take. Furthermore, Dr Bani Ghosh and Dr Joyshree Roy share the pedagogy of experiential learning as applied to climate change action of Sulphur 2020 cap and its business impact, as a case study to access capacity building in maritime education.

Digitalization that is making inroads into shipping has 2 papers dedicated to different aspects of the industry. Mr Kaushik Seal eulogizes data analytics for enhancing fleet performances. Digitalization provides the means to manage complexity by automating rule-based evaluation of large amounts of data that would otherwise require enormous human effort. I dwell into the contentious issues of digitalizing maritime education and training and highlight the dangers of careless initiatives in safety critical operations like those of our industry.

Human element and Safety will continue to be central themes for much more time to come until the much hyped 'autonomous ship' becomes commonplace. Dr Aprajita in her paper argues that the industry is yet not fully sensitized to the real dangers of seafarer's fatigue and its consequences and bursts some myths on the subject. Dr Nippin in his distinctive style raps the industry yet again on promoting safety without much thought to the means.

The papers presented in this issue are a significant contribution to the literature as they provide much thought-provoking debate required to ensure that the industry remains alert, responsive and meaningful.

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SEAFARER FATIGUE: ARE WE RECEPTIVE TOWARDS ITS CONSEQUENCES

Dr. Aprajita Bhardwaj

Abstract

Seafarers' fatigue has been identified as a contributing factor in a number of maritime accidents. While regulatory authorities have proposed certain minimum guidelines to manage fatigue, the expectation of the stakeholders is that the seafarers are responsible to manage and tolerate fatigue as part of their working life at sea. The current demands of the shipping, with no or little support from the shore based personnel, makes a seafarer highly fatigued, compromising the safety of the ship. Recent researches on seafarers highlight the fatigue-related problems peculiar to the shipping industry. Through this paper an attempt is made to sensitize the stakeholders to seafarer fatigue, with the aim of finding suitable solutions.

***Key words**:* Maritime Fatigue Safety; Maritime; Fatigue; Seafarer; Shipping; Fatigue Risk Management.

1. INTRODUCTION:

Human fatigue is recognized as being one of the primary causes of accidents in industry today. The costs of fatigue are a major human and financial burden to companies, workers, and their families.

Shipping, like other transport industries (rail, aviation, commercial road transport) works a twenty-four-hour continuous operation. Ship owners and operators are obliged to seek economic efficiencies, as a result, reduce the number of shipboard crew, which implies more demanding working conditions for seafarers. Seafarers have to work long and irregular hours for long periods of time and are frequently subjected to restricted and interrupted sleep, high workload, poor eating habits, poor sleeping conditions, social isolation and no clear separation between work and recreation.

Fatigue has become a key concern within shipping because the operational aspects associated with the industry are more complex than those associated with other industries. For example, variety of ship types, the pattern and length of sea passage, the number of port visits and the non-standardized port stay, all present unique combinations of potential causes of fatigue.

Regulations, Compliance and Safety:

Seafarers currently engaged in international trade generally have their hours of work and rest governed by the provisions of the STCW Convention 2010, Manila Amendments, as interpreted by the Flag State of the vessel on which they are serving.

Prescriptive hours of work and rest limits set out in the International Maritime Organization (IMO) and the International Labour Organization (ILO) Conventions are considered to be the primary fatigue risk management requirements, setting minimum standards of compliance in international shipping (Grech 2016).

Despite efforts directed at mitigating the risk of fatigue through the adoption of hours of work and rest regulations and development of codes and guidelines, fatigue still remains a concern in shipping. Lack of fatigue management has been identified as a contributory factor in a number of recent accidents. These approaches mainly focus on prescriptive hours of work and rest and include an individualistic approach to managing fatigue. The expectation is that seafarers are responsible to manage and tolerate fatigue as part of their working life at sea.

Ships' crews are under increasing pressure from competitive voyage schedules and have to handle their tasks with fewer crew members. The rules imposed by the company management may be stressful to the seafarers. Additionally, it is very difficult for seafarers to comply with all the existing regulations due to the harsh conditions on board ships. Consequently, the effort for compliance with national/international rules and regulations becomes a source of stress, leading to fatigue, subsequent impairment of alertness and affecting maritime safety.

Fatigue has been linked to a substantial share of groundings, and may also be linked to collisions. An analysis of accident investigation reports of groundings, reveals that irregular working hours, inadequate task allocation and high demands are common antecedents of fatigue-related groundings, and that fatigue is a factor in 41 per cent of groundings (Phillip 2014). There has been very little evidence based research concerning fatigue at sea prompting the significant studies in this area.

Seafarer Fatigue: Significant Researches and their Findings:

A study into seafarer fatigue was undertaken by Cardiff University's Centre for Occupational and Health Psychology (COHP, 2006), supported by several UK-based shipping bodies, mostly on UK flagged vessels. The findings of that study concluded that:

- Seafarers commonly worked excessive hours, falsifying of records was common, frequent port calls led to greater fatigue, Mini-bulkers suffered worst. Poor sleep quality increased fatigue as did negative environmental factors, high job demands and high stress.

In 2012, 'Project Horizon' a European Commission part funded multi-partner research initiative was set up to scientifically investigate seafaring watch keeper fatigue. The results of the project confirmed several high-risk situations:

- Watch keepers were found to be most tired at night and, to lesser extent, in afternoon.
- End of watch was the worst time for sleepiness, especially at night. Their slowest reaction times at end of night watches.
- 6 on 6 off was found to be more tiring than 4 on 8 off. Watch keepers had markedly less sleep than those seafarers on 4 on 8 off. Onset of tiredness occurred over shorter timeframe.
- Passages through difficult waters was found to be particularly high risk.

Project MARTHA was set up in 2014 and the final report was published in February 2017. The research and surveys in Project MARTHA were carried out by a number of educational institutions from China, Denmark, Sweden and the UK. It differentiated between sleepiness and the other effects of fatigue.

The results from the MARTHA project have indicated that

- Fatigue and stress increase for most crew as the voyage length increases, and motivation decreases.
- Captains suffer more than their colleagues from both fatigue and stress.

- Port work was found to be particularly demanding.
- No one on board gets adequate sleep, with the night watch keepers being particularly at risk of falling asleep.
- High sleepiness levels can occur at any stage of the voyage but the quantity and quality of sleep deteriorates over long voyages.

Merely ensuring that a crew member receives the minimum legal amount of rest under STCW and MLC is not a guarantee of avoiding fatigue.

Fatigue Management: Ground Reality:

While the shipping industry is now mindful of the importance of managing fatigue, both in terms of sleepiness and also in its longer term psycho-social effects, not much is being done to reduce its impact. Records are regularly falsified in order to appear to be in compliance. Rest hour regulations cannot be met, and schedules remain unchanged, further additional crew are not provided where ever required. The master is not empowered and supported by shore management to actively enforce hours of rest regulations, including stopping the ship if necessary.

There are systems that can be employed to minimise the risks of fatigue. These include addressing fatigue from a regulatory (record-keeping) point of view and the adoption of fatigue risk management. Fatigue Management Systems have been implemented in the aviation and road transport industries where it has been realised that fatigue is a hazard that can be effectively managed like any other risk. However, in the shipping industry there have been many cases where non-conformances have been raised because ships' crews have made errors in their record-keeping, due to commercial pressures and other factors beyond their control.

The implementation of a Fatigue Management Plan for the seafaring industry will only be effective if there is commitment shown by all stakeholders, from senior shore management downwards throughout the organisation. The chances of failure for the plan would be high if the over-riding culture, one which embraces the traditional maritime attitude, and ignores the fact that fatigue is dangerous to personnel, ships, cargo and company. While the policy makers and the seafarer may be aware of the consequences of fatigue, there seems to be a void as far as the ashore personnel are concerned about its sensitive implications towards all the players. The need of the hour is to bring about the awareness about the consequences of seafarers' fatigue to all concerned.

2. FATIGUE: AN OVERVIEW:

Given below is a general overview of fatigue, its causes and consequence and potential effects on maritime personnel.

Definition of Fatigue and IMO Guidelines:

The International Maritime Organization (IMO) has defined fatigue as the diminution in the physical or mental capacity as a result of physical, mental or psychological exertion, which has weakened the physical abilities, including strength, speed, response time, hand-eye coordination and decision-making. (MSC, 2001)

In another definition by the ICAO has defined fatigue as a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties. (International Civil Aviation Organization)

Both the definition focus on the reduced physical, mental and psychological functions due to increased exertion and reduced sleep.

IMO Guidelines (2001) have categorized seafarer fatigue into four general factors.

(a) Crew-specific factors: sleep and rest, working hours, skills and experience
(b) Management factors (ashore and on board):

1. Organizational Factors – Staffing Policies and requirement, Company culture and management style, rules and regulations, economics, training and selection of the crew

2. Voyage and scheduling factors: level of manning, frequency of port calls, paperwork requirements, time between ports, traffic density on route, nature of duties and workload while on ports, weather and sea conditions on route.

(c) Ship-specific factors: level of automation, age of ship, equipment reliability, inspection and maintenance accommodation environment, physical comfort in work spaces,

(d) Environmental factors: noise, vibration temperature, weather and sea conditions, traffic density, and interpersonal relationships.

Distinguishing Sleepiness and Fatigue:

Sleepiness and Fatigue are separate but related phenomenon and it is essential to distinguish between the two.

Sleepiness is a short-term phenomenon experienced by healthy individuals. It has a rapid onset, is of a short duration, may be due to a single cause and impacts a short-term effect on daily activities.

Fatigue, on the other hand, is long term consequence of physical, mental and psychosocial exertions, may cause health disorders (physical and mental). It has an insidious onset which persists overtime. It is due to multiple factors and can significantly affects behaviour and wellbeing.

Fatigue, Alcohol and Performance Impairment:

The performance impairment caused by fatigue was compared with that due to alcohol intoxication, and results indicated that relatively moderate levels of fatigue impair performance equal to or greater than what is currently acceptable for alcohol intoxication (mean blood alcohol concentration 0.10%) (Dawson, Reid, 1997). Performance decreased significantly in both conditions especially, hand-eye coordination.

This implies that a moderately fatigued seafarer may not be the best person to be given ship related responsibilities as his performance may be compromised. Sadly, this is not the case as a seafarer has to shoulder multiple responsibilities due to the reduced staffing policies at sea.

3. CONSEQUENCES OF FATIGUE:

Fatigue degrades performance and mental abilities. Fatigue has been associated more with skill-based errors, knowledge based errors or violations. Fatigue due to monotony has been associated with less frequent checking behaviour and increased effort. As fatigue increases errors of omission and commission to increase, leading to micro sleep. Fatigue can cause uncontrolled and involuntary shutdown of the brain regardless of the how hard one tries, irrespective of the level of competence, or the training of the person.

- A fatigued worker may seem sleepy, irritable, sad or giddy
- Fatigue can reduce mental and physical abilities and may increase risk-taking
- Fatigue can cause workers to fall asleep unintentionally
- Extended work hours can contribute to worker fatigue

Cognitive Processes Slow Down: alertness declines, the brain shuts down to conserve energy, involuntary lapses into sleep increase over time; *attention, perception and decision making* abilities are impaired.

Attention Span Narrows**:** Inattention to minor, but potentially important details occur; lapses of attention increase; greater time lapses occur as fatigue increases.

Memory Problems**:** The ability to integrate, store, and retrieve information declines when the worker is fatigued.

Reaction Time: slows down and becomes irregular relevant cues are missed as a result. Cross checking declines, taking too much mental effort and time.

Flawed Decision Making: Decisions are made on missed, flawed, or based on incomplete information. Thought processes suffer, as the ability to logically reason is impaired. The person experiences difficulty concentrating and thinking clearly. Mental skills decline and everything becomes more difficult to perform, even simple tasks.

Mental Tasks Harder to Perform**:** Tasks involving Mental arithmetic, programming, entering data, remembering are compromised.

- Short-term recall and working memory performance decline.
- Performance requiring divergent thinking deteriorates.
- Performance deteriorates as task duration increases.

- Increased likelihood of finding ineffective solutions.

Perceptual Changes: Channelling of attention, Tunnel Vision, Tunnel Hearing are commonly observed.

Attitude Problems: Attitude and mood deteriorate. “It’s good enough” attitude prevails, psychological depression, poor morale is observed. Person experiences increased irritability about little things and becomes more moody.

Teamwork Problems: Communications between the team members’ breakdown leading to a decline in social interactions. It impairs cooperation, and team coordination.

Performance Problems: Performances lowers as accuracy and timing degrade critical actions.

- Inadequate crosschecking of relevant cues leads to poor and careless performance, and increased errors.
- Lower standards of performance become acceptable and the person may develop greater tolerance for error.

Physical Symptoms Increase: Increased dizziness, headaches, and stomach aches are experienced.

Long term consequences of fatigue:

Greater psychological distress, poorer general health and more frequent visits to the doctors have all associated with both fatigue risk factors (such as work stress and job demand) and fatigue. Worsening work characteristics have been associated with increased fatigue over time, and consequently increases in fatigue have been found to deteriorate psychological and general health. Recovery from fatigue after a tour of duty on average does not occur until the second week of leave. The impact of fatigue in the industry may, therefore, be much greater and more widespread than watch-keeping and accident statistics imply.

FATIGUE: its Consequences and Impact:

Consequences	Impact
• Slowed reaction time • Reduced vigilance • Memory lapses • Inattention to tasks • Complacency • Lack of awareness, communication and Judgment • Decline in motivation • Micro-sleep	• Long term health issues (obesity, cardiovascular, gastrointestinal, diabetes) • Psychological Distress • Low Morale, absenteeism and turn-over • Health-injuries, sleep disorders • Lost productivity • Equipment and property damage • Work cover claims

4. FACTORS CONTRIBUTING TO FATIGUE:

***Sleep Loss and Sleep Debt*:** Sleep restriction severely degrades performance. When sleep is less than 6 hours per night, fatigue becomes a problem almost immediately. When sleep is cut to less than 4 hours per night, uncontrolled micro sleep attacks occur. When sleep loss becomes cumulative it results in sleep debt. Research shows 10 days of restrictive sleep leads to progressively worsening performance and eventually lead to a zone of impairment of abilities.

***Jet Lag or Shift Work*:** is an abrupt change in environmental time. It leads to disturbed sleep, increased drowsiness, decreased physical or mental performance, increased reports of fatigue, more negative moods, and gastrointestinal problems.

***Circadian Rhythm Disruption*:** are caused mainly due to Jet Lag and Shift Work. Symptoms are manifested as Disturbed Sleep Patterns, Decreased Performance, and Gastrointestinal Problems.

***Boring / Repetitious Work*:** Research has demonstrated that monotonous vigilance tasks decreased alertness by 80% in one hour and is referred to a “Boredom Fatigue”. Boredom and monotony are widely recognized as undesirable side effects of repetitive work.

***Prolonged Work*:** usually leads to fatigue because of cumulative sleep loss leading to sleep debt.

The seafarer travels across time zones, mostly joining the vessel on arrival. He gets into shift work immediately leading to Circadian Rhythm Disruption, sleep loss and sleep debt. Fatigue increases most significantly during the first week of voyage has been reported by the Cardiff University Project on Fatigue (2006).

The potential for fatigue at sea is high due to seafarers' exposure to a large number of recognisable risk factors, both operational (*e.g*. port frequency), organisational (*e.g*. job support), and environmental (*e.g*. physical hazards).

5. COMMON MISCONCEPTIONS ABOUT FATIGUE:

"I know how tired I am "or "I can tell when I'm going to fall asleep": The more tired one becomes, the less able he is to make a good judgement about his ability to remain awake, or recognise that his performance is deteriorating. We are all bad judges of how fatigued we actually are.

"I've lost sleep before and done just fine" or *"I'm motivated enough to push through it" or I'm really experienced, I can fight off any feelings of fatigue*: One cannot simply "decide" to feel less tired. Although intense concentration may help for a short period, fatigue cannot be overcome by willpower, experience or motivation. The only remedy for fatigue is sleep.

Fatigue can be managed by addressing working time arrangements: Fatigue isn't just about managing working time. Fatigue can also be made worse by workplace conditions. High-pressure demands, poor lighting, constant noise, heat, cold, vibration and even poor weather can make the seafarer feel more tired.

Our bodies get used to working shifts: If one is working when he should normally be sleeping, or sleeping when one should normally be awake, one will be fighting against his natural instincts to work during the day and sleep at night.

Exercises is a safe guard against Fatigue: Physical Fitness is not a safeguard against mental fatigue. Organizations have historically tried to decrease fatigue susceptibility by improving physical fitness. This strategy works well in jobs which require physical labour.

My Crew Will Tell Me When They're Tired: Individuals can't accurately gauge their own level of impairment, due to sleep loss. Senior officers and team members must learn to look for the symptoms of sleep loss in others.

You can't tell if someone is fatigued: There are symptoms that may indicate a worker is fatigued, such as short term memory problems, an inability to concentrate, impaired decision-making, slow reflexes and withdrawal from interpersonal communication.

6. PREVENTIVE MEASURES TO COMBAT FATIGUE AT SEA:

Jet Lag: After travel across time zones, physical and mental resources lag behind while adjusting to the rapid change at the destination, light/dark cycle and the new sleep and work schedule. 1-day recovery is recommended for every time zone crossed to restore normalcy.

Develop Proper Shift Schedules: Schedule teams in ways that ensure enough daily sleep.

Good Sleep Habits: Use sufficiently bright lights in the work environment during the night shift in order to resynchronize the circadian timing system to the nocturnal schedule. Maintain complete darkness in daytime sleeping. Follow a consistent sleep-and meal-timing schedule from day to day. Emphasize Sufficient Sleep on a Daily Basis. 7 hours per night is the minimum requirement.

Napping: Controlled Napping can maintain or restore performance when sleep is shortened, disrupted, or missed altogether. When napping, it is best to either get up after 30 minutes or sleep through a full sleep cycle which is an hour and a half. When possible, allow time for sleep inertia to dissipate which is usually from 30 - 45 minutes after waking up.

Lifestyle: Exercise regularly, avoid alcohol and caffeine at bedtime and eat a balanced diet.

7. MANAGEMENT OF FATIGUE: Long Term Perspective

The potential for fatigue at sea is high due to a range of factors, many unique to the marine environment. Fatigue has been consistently associated with poor quality sleep, negative environmental factors, high job demands and high stress. Other important factors contributing to fatigue included frequent port turn-around, physical work hazards, working more than 12 hours a day, low job support and the switch to port work.

Fatigue at sea would appear to be more prevalent than the seafaring community is currently able to gauge. In an industry where market competition can result in compromised standards, this concern needs to be addressed as fatigue, due to its crucial role in maritime casualties, pose a great risk to human life and property, as well as to the marine environment.

Fatigue can be addressed at three levels: legislation, company policy and personal awareness/management. Success will only be achieved if all three are co-operatively involved. The way forward is to treat seafarers' fatigue as a serious health and safety issue. A starting point must be to take a more robust approach to regulation.

Ship owners could provide sufficient support to vessels with a sufficient number of crew members suitable to the nature of work on board. Manning levels need to be addressed in a realistic way. This must be supplemented with appropriate training and guidance regarding avoidance of fatigue and the creation of optimum working conditions. This approach will only be effective if crew are empowered to act on their training in terms of actively intervening with operations when required.

The introduction of Fatigue Risk Management Systems, as already used in other safety-critical transport systems, presents an integrated systems approach to managing the risk of fatigue. It requires ownership by all in the company, provide changes in culture and can be introduced in a gradual process as the company develops its own approach. (Project Martha, 2017)

Activating the role of educational institutions responsible for training seafarers to raise awareness among trainees about the dimensions of fatigue, its symptoms and it's the short term and long term impact, as well as possible prevention precautions, are some of the ways to manage fatigue at sea.

REFERENCES:

Allen. P., Wadsworth. E., Smith. A. (2008) - Seafarers' Fatigue: A Review of the Recent Literature Internat. Marit. Health, 2008, 59, 1 – 4

Dawson D. and Reid K. (1997) Fatigue, alcohol and performance impairment. *Nature* Vol 388, page235 (1997)

Loss Prevention Briefing for North Members (20017) Copyright © The North of England P and I Association Limited 2017 (February 2017)

Phillips, R.O., (2014) What is fatigue and how does it affect the safety performance of human transport operators? Fatigue in Transport Report I., Institute of Transport Economics, Norway ISBN 978-82-480-1562-8 Electronic version

Project Martha – The Final Report (2017) The Centre for Maritime Health and Society, University of Southern Denmark:

Seaways (2006) Fatigue: IMO Guidance, 7-9, March

Smith A. (2006) Adequate Crewing and Seafarers' Fatigue: The International Perspective, Centre for Occupational and Health Psychology, Cardiff University. 2006.

Smith. A., Allen. P., Wadsworth. E. (2006) Seafarer Fatigue: The Cardiff Research Programme, Centre for Occupational and Health Psychology, Cardiff University

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REGULATORY REGIME GOVERNING MARITIME AIR POLLUTION AND LEGAL COMPLIANCE ALTERNATIVES IN ERA OF SULPHUR CAPPING 2020

Dr. (Capt.) Vivek Jain
Dr. Iris Jiyeon Kim

Abstract

In the last few decades, *MARPOL* has significantly contributed in preventing and minimising pollution from ships due to both operational and accidental issues. In the era of increasing sea-borne trade and worldwide awareness of global warming, the need for combating air emissions at sea has gathered pace. *MARPOL Annex* VI that entered into force on 19 May 2005 seeks to limit the air pollutants from the exhaust gases that are emitted from the merchant's vessels. *MARPOL Annex VI* has been amended over the years, in particular: a) pursuant to MEPC 63 adopted in March 2012, it mandates four sets mandatory regulations on Energy Efficiency for Ships in *MARPOL Annex VI,* and b) pursuant to *MEPC 70* in October 2016; the fuel oil standard (0.50% sulphur limit) shall become effective on 1 January 2020. This complying fuel oil is available at a higher price in the market. At this stage, there is underlying uncertainty about the availability, as well, of such fuel notwithstanding at a higher price at most of the bunkering ports. This uncertainty has a potential to increase even further in light of increasing demand for such fuel due to regulatory constraints. However, *MARPOL Annex VI, Chapter 1, Regulation 4* has provided ship owners and operators with an alternative path to the above-stated compliance by using exhaust gas cleaning systems also known as a SOx scrubber. There are equally important other alternatives to achieve compliance, for example, by changing the fuel composition through fuel blending, by improving and enhancing engines by replacing the fuel to LNG. At the same time, in many cases, such alternatives are not easy to implement due to various reasons.

In this interdisciplinary paper, an attempt is made to provide guidance to distinct stakeholders, including ship owners, ship management companies, and others on such alternatives, including associated feasibility study while complying with relevant regulatory regime.

Key words: MARPOL Annex VI, Scrubber, Open Loop, Closed Loop, High Sulphur and Low Sulphur Fuel, Emission Control Areas, LNG

1. INTRODUCTION AND REGULATORY REGIME:

It is very important to discuss the regulatory regime affecting the issue of maritime pollution to understand the compliance alternatives for combating air pollution regulations. The paper will first analyze the Regulatory regime and its evolution in context of regulations affecting merchant ships that operate on oceans and seas.

MARPOL:

The International Convention for the Prevention of Pollution from Ships (hereinafter "MARPOL") is the main international convention pursuant to Public International Law applicable to the marine Industry. It encompasses a wide area that seeks to prevent and minimise pollution of the marine environment by ships. The proximate cause of pollution from ships could stem from both the operational or accidental issues. A series of tanker accidents in mid-1970s led to adoption of the *MARPOL Convention 1973* with added *Protocol 1978.* It took further five years before it entered into force on 2nd October 1983.

MARPOL comprise of six technical Annexes. All of these Annexes further embrace an idea of Special Areas with strict controls on operational discharges. The six Annexes are as follows:

- *MARPOL Annex I* comprise of regulations for the Prevention of Pollution by Oil. It has entered into force 2nd October 1983 and further revised in 1992, 2002 and 2003.
- *MARPOL Annex II* comprises of regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. It has entered into force on 2nd October 1983.
- *MARPOL Annex III* comprises of regulations for Prevention of Pollution by Harmful Substances (as identified by International Maritime Dangerous Goods Code popularly called as IMDG Code, as marine pollutants) Carried by Sea in Packaged Form. It has entered into force 1 July 1992**.**
- *MARPOL Annex IV* comprises regulations for Prevention of Pollution by Sewage from Ships. It entered into force on 27 September 2003.
- *MARPOL Annex V* comprises regulations for Prevention of Pollution by Garbage from Ships. It entered into force on 31 December 1988.

MARPOL ANNEX VI:

In the era of increasing sea-borne trade and world-wide awareness of global warming, the need for combating air emissions at sea has gathered pace. *MARPOL Annex VI* entered into force on 19th May 2005, and accordingly seeks to limit the air pollutants from the exhaust gases that are emitted from the merchant vessels. *MARPOL Annex VI* has been amended over the years, in particular: a) pursuant to Marine Environment Protection Committee (*MEPC 63)* adopted in March 2012, it decrees the four sets of mandatory regulations on Energy Efficiency for Ships in *MARPOL Annex VI*, and b) pursuant to *MEPC 70* in October 2016; the fuel oil standard (0.50% sulphur limit) shall become effective on 1st January 2020. This complying fuel oil is usually available at higher price; however, *MARPOL Annex VI*, *Chapter 1*, *Regulation 4* has provided ship-owners and operators with an alternative path to the above stated compliance and one such method will include exhaust gas cleaning systems also known as a scrubber. This will be discussed in later half of this paper.

As the issues of global warming seize the human imagination, the issues associated with risks of pollution at sea take the center stage in the maritime sector of the industry. Risks for pollution at sea include air pollution at oceans due to movement of merchant ships in oceans. For many years, *MARPOL* has set the framework for relevant regulations governing the Pollution from Ships. *MARPOL* has many Annexes and *Annex VI*, in particular, deals with the Regulations for Prevention of Air Pollution from Ships (hereinafter "*MARPOL Annex VI"*). This evolving framework is increasingly important in light of the fact that there has been increased in the size of the merchant fleet and volume of cargo that can be carried over the seas (please refer to Annex 1 to the Paper).

MARPOL ANNEX VI in relation to air pollution from ships was considered as far back in 1973 but was not included in the regulations. In 1979, in Geneva, the first international legally binding Convention on Long-range Transboundary Air Pollution was agreed by 34 governments and the European Community. It was followed by Protocols - on reducing sulphur emissions in 1985, controlling emissions of nitrogen oxides in 1988, controlling emissions of volatile organic compounds in 1991 was agreed upon. In 1994, it was followed later by further mandating requirements to reduce sulphur emissions. In 1987, the *Montreal Protocol* on substances that deplete the Ozone Layer was signed to cut consumption and production of ozone-depleting substances, including chlorofluorocarbons (CFCs) and halons in order to protect the ozone layer. This in itself was followed by two Protocols to *Montreal Convention* banning ozone-depleting CFCs and HCFCs and methyl bromide. In 1980's, IMO's *Marine Environment Protection Committee* (hereinafter "MEPC") did consider air pollution in 1980s, but it was limited to the issue of fuel quality, and in respect to *MARPOL Annex 1*. In 1988, MEPC started discussing the issue of air pollution from ships more actively, and it led to the adoption in 1991, of an IMO Assembly Resolution A.719 (17) on *Prevention of Air Pollution from Ships*. It ultimately led to *Annex VI to MARPOL*. However, *Annex VI* to *MARPOL* pertaining to air pollution from the ships was first adopted in 1997, and thereafter entered into force 19 May 2005.

For the sake of completeness, MARPOL Annex VI was implemented in the United States through the Act to Prevent Pollution from Ships, *33 U.S.C. §§ 1901-1905 ("APPS").* The requirements pursuant to this apply to vessels operating in U.S. waters as well as ships operating within 200 nautical miles of the coast of North America, also known as the North American Emission Control Area (ECA).

It is important to highlight the main purpose of the *MARPOL Annex VI* is to set the guidelines to limit the air pollutants from the exhaust gas emitted from the merchant vessels. The gases that are contained in exhaust gas are Sulphur oxides (SOx) and Nitrous oxides (NOx), and such guidelines also prohibit deliberate emissions of ozone-depleting substances. The *MARPOL ANNEX VI* includes, in particular, the following:

- A global cap of 4.5% m/m on the sulphur content of fuel oil; and
- Allowed for special *SOx Emission Control Areas* (hereinafter "*SECAs*") to be established with more stringent controls on sulphur emissions, where the sulphur content of fuel oil used on board, the ships must not exceed 1.5% m/m; and
- New installations containing ozone-depleting substances are prohibited on all ships; and
- New installations containing hydro-chlorofluorocarbons (HCFCs) are permitted until 1 January 2020; and
- Annex VI also sets limits on emissions of nitrogen oxides (NOx) from diesel engines. A mandatory *NOx Technical Code*, was adopted by the Conference under the cover of Resolution 2; and
- The Annex also prohibits the incineration on board the ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

Revised MARPOL ANNEX VI:

Over the years, there has been technological improvement and more awareness of risks of air pollution has evolved from the time *ANNEX VI to MARPOL* was adopted in 1997. *MEPC* in July 2005 agreed to revise *MARPOL Annex VI* and three years later, *MEPC 58* in October 2008 adopted the revised *MARPOL Annex VI* and the associated *NO_x Technical Code 2008*, which entered into force on 1st July 2010. The key changes introduced by the *Revised MARPOL Annex VI* were:

- Introduction of *Emission Control Areas* (hereinafter "ECAs") to reduce emissions of those air pollutants further in designated sea areas; and
- Progressive reduction of global emissions of SO_x, NO_x.; and
- The global sulphur cap will be reduced from current 3.50% that is in place from 1st January 2012 to 0.50%, effective from 1 January 2020; and
- The limits applicable in ECAs for SOx and particulate matter were reduced to 1.00%, beginning on 1 July 2010 (from the original 1.50%); being further reduced to 0.10 %, effective from 1 January 2015. For the sake of completeness, in many geographical areas, there are more stringent requirements, for example, in EU, where ships transiting EU ports y are subject to a 0.1% sulphur limit for a while.
- Progressive reductions in NOx emissions from marine diesel engines installed on ships are also included, with a "Tier II" emission limit for engines installed on or after 1 January 2011; then with a more stringent "Tier III" emission limit for engines installed on or after 1 January 2016 operating in ECAs. Marine diesel engines installed on or after 1 January 1990, but prior to 1 January 2000 are required to comply with "Tier I" emission limits, if an approved method for that engine has been certified by an Administration; and
- The revised *NOx Technical Code 2008* includes a new chapter based on the agreed approach for regulation of existing (pre-2000) engines established in *MARPOL Annex VI*, provisions for a direct measurement and monitoring method, a certification procedure for existing engines, and test cycles to be applied to Tier II and Tier III engines.

SOx and Emission control areas:

MARPOL Annex VI, Chapter 3, Regulation 14 provides for General Requirements in relation to Sulphur Oxides ("SOx") and is as follows:

1) *The sulphur content of any fuel oil used on board ships shall not* <u>*exceed 4.5% m/m*</u> <u>[emphasis added]</u>; *and*
2) *The world-wide average sulphur content of residual fuel oil supplied for use on board ships shall be monitored taking into account guidelines to be developed by the Organization.*

a. In addition, same regulation provides for *SOx Emission Control Areas* as follows:

3) *For the purpose of this regulation, SO_x emission control areas shall include: the Baltic Sea area as defined in regulation 10(1)(b) of Annex I, the North Sea area as defined in regulation 5(1)(f) of Annex V; and b) any other sea area, including port areas, designated by the Organization in accordance with criteria and procedures for designation of SO_x emission control areas with respect to the prevention of air pollution from ships contained in appendix III to this MARPOL Annex VI.* (Please refer to Annex II to this paper)

Further amendments to revised MARPOL ANNEX VI:

Over the years, amendments were made to *MARPOL ANNEX VI* that was adopted in 1997 and are in force from 19 May 2005. In addition, pursuant to the amendments to Revised MARPOL ANNEX VI provides:

- Resolution *MEPC 62* adopted in July 2011 and entered into force from 1 January 2013, with the amendments to *MARPOL Annex VI* (resolution *MEPC.203 (62)*, the *Energy Efficiency Design Index* (hereinafter "EEDI") was made mandatory for new ships and the *Ship Energy Efficiency Management Plan* (hereinafter "SEEMP") for all ships. EEDI mandates the use of energy-efficient equipment and engines on board the vessel and is measured by energy efficiency level per capacity mile. IMO has used a non-prescriptive approach for the industry to decide the design provides there is a gram CO2 reduction per mile with reference line being the ships built between 2000 and 2010. The requirements related to the EEDI will progressively become onerous every five years. Another aspect of the resolution is SEEMP, which is an operative measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner using a voluntary use of the *Energy Efficiency Operational Indicator* (hereinafter "EEOI") pursuant to (*MEPC.1/Circ.684*).
- Pursuant to *MEPC 63* adopted in March 2012, it mandates four sets of important guidelines to assist in the implementation of the mandatory regulations on Energy Efficiency for Ships pursuant to *MARPOL Annex VI.*
- Pursuant to resolution *MEPC.212(63)* in 2012 - Guidelines on the method of calculation of the attained *Energy Efficiency Design Index* (EEDI) for new ships.

- Pursuant to resolution *MEPC.213(63)* in 2012 - *Guidelines for the development* of a Ship Energy Efficiency Management Plan (SEEMP).
- Pursuant to resolution *MEPC.214(63*) in 2012 - *Guidelines on survey* and certification of the Energy Efficiency Design Index (EEDI).
- Pursuant to resolution *MEPC.215(63) - Guidelines for calculation of reference* lines for use with the Energy Efficiency Design Index (EEDI).
- Pursuant to *MEPC 7*0 in October 2016 – It considered an assessment of fuel oil availability to inform the decision to be taken by the Parties to *MARPOL Annex VI*, and decided that the fuel oil standard **(0.50% sulphur limit) shall become effective on 1st January 2020.**

2. COMPLIANCE WITH NEW REGULATORY REGIME (effective 1 January 2020):

On merchant ships ordinarily having large marine diesel engines, it is observed that typical heavy fuel oil has an average sulphur content of 2.7%. During the combustion process, the sulphur is oxidized to sulphur dioxide (SO2).

We have discussed the new regulations and the requirements pursuant to *MARPOL ANNEX VI* in the regulatory regime applicable from 2020. Owners, in order to comply with the new regulations in relation to new fuel standard, will have to contemplate a switch to distillate fuel. These fuels complying with the regulations are available at higher prices, but also will raise additional concerns on board the ships, in particular, to the operating difficulties involving low viscosity, lubricity, lower flashpoints and catalytic fines. Fortunately, *IMO/MARPOL ANNEX VI,* Chapter *1, Regulation 4* has provided ship-owners and operators with an alternative path to *MARPOL ANNEX VI* compliance by using exhaust gas cleaning systems also known as scrubbing.

For the sake of completeness, *MARPOL Annex VI, Chapter 1, Regulation 4* provides:

> *The Administration of a Party may allow any fitting, material, appliance or apparatus,* **such as SO_x scrubbers** [emphasis added], *to be fitted in a ship* ***or other procedures, alternative fuel oils, or compliance methods used as an alternative to that required by MARPOL Annex VI*** *[emphasis added]***.**

The Administrations of Party that allow a fitting, material, appliance, apparatus or other procedures, alternative fuels, or compliance methods used as an alternative to that required by MARPOL Annex VI shall advise IMO on it. Notifications of use of equivalent provision from Parties are available through the Global Integrated Shipping Information System ***(GISIS)****. (Registration required for public users).*

3. THE FOUR MAIN MODES TO OVERCOME 2020:

As discussed above, pursuant to the amendments to *MARPOL Annex V*I, IMO will enforce a new 0.5% global sulphur cap on fuel content from 1 January 2020. This measure will ensure to limit the global air pollution and also assisting populations living close to ports or the coasts that are not within *Sulphur Emission Control Areas* ("SECAs"). SECAs restricts the mass of Sulphur Oxide to just 0.1% m/m. SECs being the Baltic Sea, the North Sea, the North American ECA, including most of US and Canadian coast and the US Caribbean ECA.

This will compel the ship owners and operators to modify and improve their ships to comply with the regulatory regime as discussed above. Pursuant to *MARPOL Annex VI, Chapter 1, Regulation 4*, there are four main common variations that ship owners and operators are currently employing - (1) use of low sulphur oxide fuel, (2) installation of SOx scrubber (sulphur oxides scrubber), (3) use of alternative fuels such as LNG, and (4) less commonly called as oil blending or solution blending. In this paper, the authors will discuss the first more common options that are being employed, before moving to the option of scrubbers.

Option 1 – Low –Sulphur oil:

The use of low sulphur oxide fuels has the discernible and understandable advantage of the lowest investment cost, but the disadvantage is that the margins in operating the vessel can decrease considerably due to the rise in fuel price as a result of instability and/or unavailability of the fuel supply at various ports

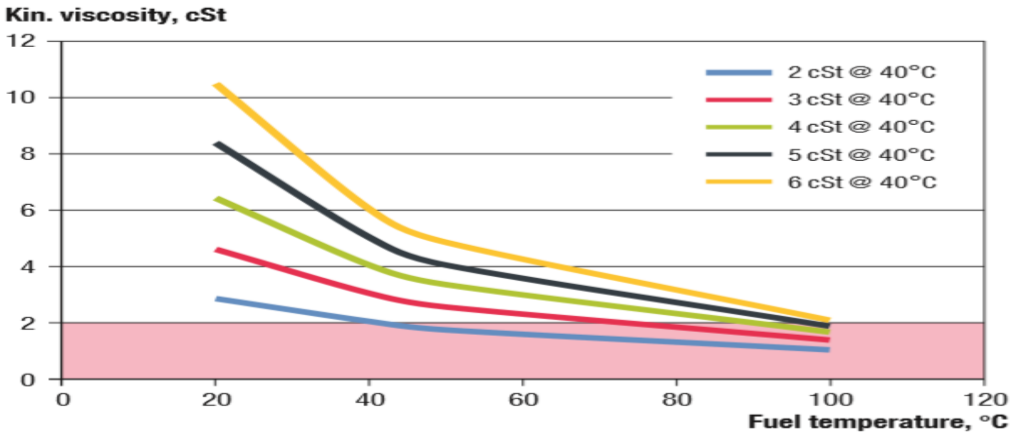


Figure 1: Temperature-Viscosity Relationship For Very Low Viscosity fuels[1]

Additionally, altering to low sulphur fuels will lead to significant increase in fuel cost. Refineries worldwide need to change its existing production system to low sulphur fuel, which is estimated currently to take more than five years. As a result, it is predicted that there may be instability and/or unavailability of fuel supply at various ports for time being.

Technically when switching from HFO to distillate oil, a slow changeover is necessary. The reason for the slow changeover is to allow adequate time for the temperature of the fuel pump to drop from 150°C to 45°C. It will accordingly prevent pumping seize; as a result of insufficient viscosity of the distillate oil might stop the pump from working efficiently.

Figure 2: Compatibility Issues with Fuel Oils

When mixing HFO with the distillate in the booster system, to have a smooth changeover, a good compatibility between the HFO and the distillate is essential. If the fuels are not compatible, it will result in the build-up of deposit, and thereby clogging filters. It can be seen as above.

[1] Guidelines for Operation on Fuels with less than 0.1% Sulphur

Option2 – LNG (Liquefied Natural Gas):

The use of alternative fuels such as LNG is basically an alternative that can lead to relatively low emission of nitrogen oxides and sulphur oxides. It has an added advantage of being available at relatively low fuel price. The complete removal of SOX and PM emissions and a reduction of NOX emissions of up to 85% can also reduce greenhouse gas (GHG) emissions by 10 to 20%, depending on engine technology.

However, the above advantages in this option come with their own disadvantages. The installation costs for employing LNG fuels are extremely high. Additionally, the process of induction on board, the merchant ships is very complicated to execute, and not all ports currently have stations that can refill the LNG tanks. The availability of LNG bunkers is gradually increasing. However, it is too early in time to eliminate the use of fuel oil or to ensure reasonable bunker infrastructure for LNG is available in ports. This may happen in a few years from now, but the date to comply with the new regulatory regime is fast approaching. This means that the owners' options are practically limited at this time to comply with the new regulatory regime.

Option 3 – Fuel Blending:

Marine engineers and technologist are currently working on this option of solution blending or oil blending. Currently, it is unreliable and meanwhile, research has not reached the state where this option can comply with the regulatory regime. Engine manufacturers are also striving to meet the new regulatory regime as to the low sulphur requirements through new innovative approaches, but they are still very limited as far as technological breakthrough that is needed is concerned.

Table-1: Comparative analysis of four options in Tabular form[2]

MAIN ALTERNATIVES	PRO	CON	APPLICATION
COMPLIANT SCRUBBER	It reduces exhaust emissions by 98% High returns on investment	Additional equipment installation required Complexity of engine and funnel area.	New shipbuilding and Retrofit for Container, Bulk carrier, *etc*.

[2] ABS Advisory On Exhaust Gas Scrubber System July 2018

MAIN ALTERNATIVES	PRO	CON	APPLICATION
LOW- SULPHUR DISTILLED OIL (COMPLIANT FUEL)	Low investment cost	Oil prices fluctuate	Present ship operating available
LIQUEFIED NATURAL GAS	Low emission of NOx and SOx	High installation costs Unavailability of LNG at all ports	Future new shipbuilding available
FUEL BLENDING	High price oil cost relatively	Effect to engine maintenances by density of oil Still research is undergoing, and compliance is doubtful.	Blending solution

Note: NOx- Nitrogen Oxides, SOx- Sulphur Oxides, LNG- Liquefied Natural Gas

Option 4 – Scrubber:

HSFO can still be used after installation of a regulatory regime compliant SOx scrubber that is also known as an *exhaust gas cleaning plant*. No changes will have to be made to the engines or fuel treatment plants by ship owners and operators. SOx scrubber installations have the advantages of reducing exhaust emissions from ships by up to 90% while still using heavy oil.

This alternative will, however, have a high initial cost, but due to use of low-cost HSFO, it will likely give a high return on investment over the years. It is estimated that the payback period of a scrubber is about one - two years based on oil price and amount of oil consumption on board the ships. The ECAs or SECAs including China, which have started to apply local limit of 0.5% local are increasing and therefore, the payback period is much shorter for ships with a higher chance of entry into the ECA zone. By a reasonable estimate, given that more than 50% of merchant's vessels are concentrated in ECAs or SECAs, a shorter payback period is expected in this option.

Due to excellent returns on the investment in short payback period, and with the applicability of new regulations in 2020, it is widely seen that increasingly the stakeholders are opting to install the scrubbers. However, procedures and debates around installation techniques to minimize the dry-dock are being discussed among engineers and naval architects. These debates in future will also contribute to reduce the installation costs of these scrubbers. Therefore, manufacturers are becoming increasingly focused on issues associated with installation of scrubbers.

4. PRINCIPLE AND TYPES OF SCRUBBER:

A scrubber (or an exhaust gas scrubbing apparatus) is a desulphurization apparatus, whereby it removes Sulphur Oxide (SO_x) from exhaust gas discharged from ship's engines and boiler. The system is made using the principle that sulphuric acid is discharged; after the sulphuric acid is removed by the water stream in the apparatus, while passing through the scrubber. This alternative is considered fully compliant of *MARPOL Annex VI Regulation 4* with regards to compliance of Sulphur. Scrubbers have been in use in the marine industry since 2015, especially in the ECA zones in Europe and North America.

Dry type scrubbers are relatively used on land. However, wet type scrubbers are applicable to ships due to fact that the space is limited on board such ships. In wet type scrubbers, a relatively more periodic maintenance is required as compared to the dry types scrubbers. There are three main types of scrubbers for vessel: *Open, Closed and Hybrid.*

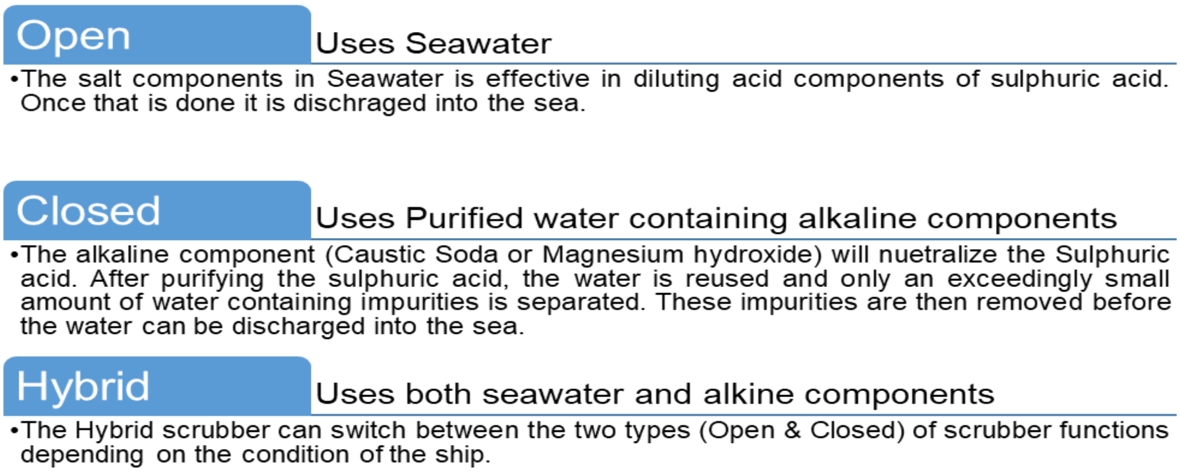


Figure 3: Overview of types of scrubbers

If one has installed an open scrubber, the marine engineers can replace bunkers when entering the port such as in Singapore, where the open scrubbers are not permitted. If low sulphur fuel is used, it may cause performance deterioration due to low viscosity in the fuel pump, cylinder, *etc*., and accordingly the viscosity should be increased to at least 2 cst and lubricant needs to be replaced. When using MGO, one needs to apply oil cooler or chiller cooling system. There are separate guidelines that are available from different engine makers, but it is advised that the engine operators should operate with more stringent standards to avoid damage to machinery.

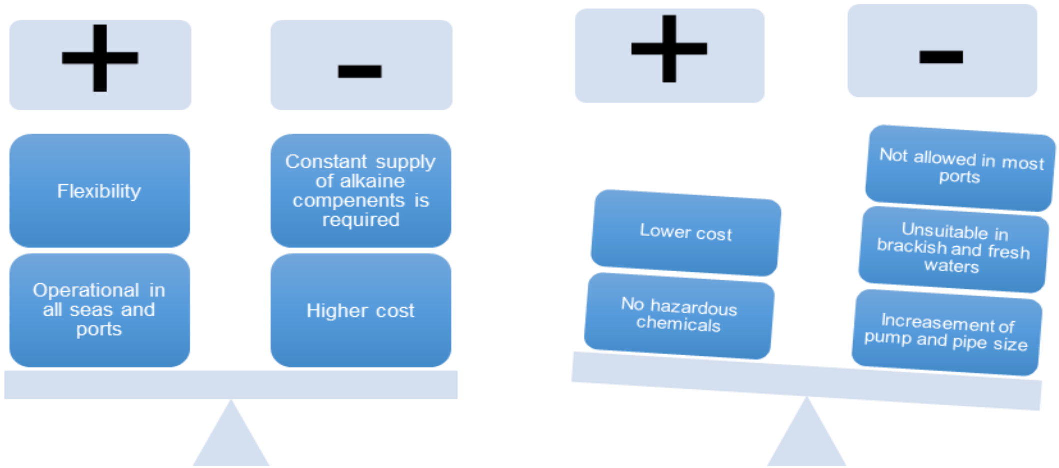


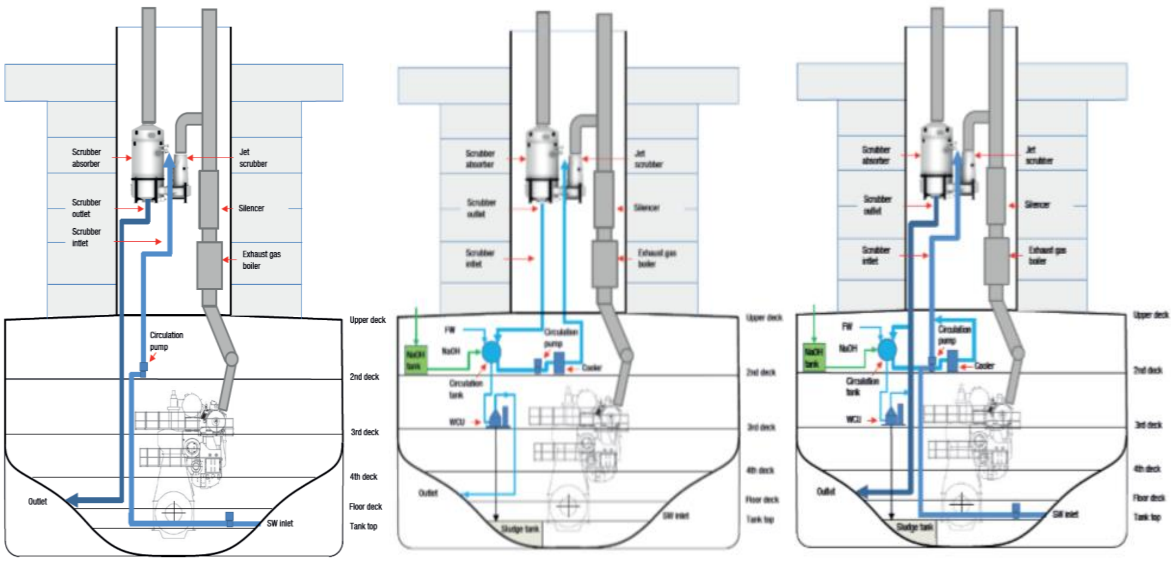
Figure 4: Pros and Cons – Closed Scrubber v. Open Scrubbers

On the other hand, according to the analysis of advantages and disadvantages for the types of scrubbers, the open loop scrubber systems usually use a large amount of seawater, consume a relatively large amount of power, and are used mainly for ocean voyages. In addition, these have to be replaced with low sulphur oxide fuel in port. However, the closed loop mainly uses fresh water and dosing unit to add NaOH for maintaining the PH values. The process tank, the water-treatment system and the heat exchangers are additionally installed as compared with open loop scrubber systems. Accordingly, they occupy a lot of space, but the power consumption is relatively less.

Hybrid scrubber systems are used as an open loop scrubber during ocean navigation and closed loop scrubber in port. It has a complicated system and requires a lot of installation space. However, it can be used while navigating in oceans and within the ports both. The scrubber market is moving from an open loop to a hybrid loop due to low operating costs after installation and due to no limitations of the operating area. Hybrid type market is expected to increase in particular, the increasingly stronger marine standards are driving the hybrid market, but in the case of a retrofit, the cost is about 30% higher. Installation costs will increase in such hybrid systems, and the level of difficulty observed will also increase.

Table-2: The Advantages and Disadvantages of different types of scrubbers in the tabular format

	Advantage	Disadvantage
Open	▪ Simple structure ▪ Simple installation/operating with lower cost	▪ Increase of pump and pipe size ▪ Restriction on the Seawater condition(pH) and local discharge regulations
Closed	▪ Reduction of drive pump and piping size ▪ No restriction on the Seawater condition (pH)/ local discharge regulations	▪ Complex structure ▪ Complicated installation/operating ▪ Higher cost ▪ Supplement of neutralizing (NaOH) needed
Hybrid	▪ Lower operating cost than closed type ▪ No restriction on the Seawater condition (PH)/ local discharge regulations ▪ Need smaller amount of neutralizing (NaOH) than closed ▪ Flexible operation according to seawater condition	▪ Complex structure (Open/ Closed scrubber) ▪ Complicated installation and operating ▪ Higher cost



Open loop type **Closed loop type** **Hybrid Type**

Figure-5: Exhaust gas cleaning systems[3]

[3] Korean Register of Shipping, Exhaust Gas Cleaning Systems Technical Information November 2018

5. THE FUTURE PROSPECT OF SCRUBBER:

Market Trends:

As discussed in Section 1 of the paper that at the 70th meeting of MEPC in London in October 2016, the International Maritime Organization (IMO) will limit emissions of ships from 3.5% m/m to 0.5% m/m by 2020 and accordingly concluded an agreement. According to the Clarkson and OECD surveys, currently, the most common options among ship owners are (1) use of low sulphur oxide fuel, (2) installation of SOx scrubber (sulphur oxides scrubber), (3) use of alternative fuels such as LNG.

The use of low sulphur oxide fuels has the advantage of the lowest investment cost, but the disadvantage is that the fuel price can rise due to instability and /or unavailability of the fuel supply. The scrubber installation has the advantages of reducing exhaust emissions from ships using heavy oil by up to 90% and the high return on investment. Due to the high initial investment costs or expectations for alternative technologies to replace them, the scrubber market has been underestimated. As the year approaches 2020, ship owners are quickly moving into the scrubber market due to the uncertainty of oil prices and the absence of economical alternative technologies.

A sharp rise in the price of a scrubber material and the delay in the material supply period prove this fact and have a great influence on the delivery period of the scrubber. In chartering contracts, it is known that the installation of the scrubber is the priority, and the main requirement of the ship owner's scrubber selection is frequently the delivery period.

The use of alternative fuels such as LNG can lead to relatively low emissions of nitrogen oxides and sulphur oxides. This is to be accompanied by a relatively low fuel price for the fuels that can be used in such systems. However, the installation cost of the LNG engine is remarkably high for installations, and the process is extremely complicated to execute on board the ships. As a result, an aggressive investment in the scrubbers is likely to be achieved by 2020. These scrubber installation agreements, market conditions and research results are particularly good opportunities for scrubber manufacturers. In addition, scrubbers are subject to an increased regulatory regime by the US Coast Guard and the EU, and accordingly they must be certified by Lions Clubs International), such as Lloyd's, DNV, and Bureau Veritas.

Table-3 Payback time of combined EGR/EGC scrubber system[4]

Engine size	Operating time	CAPEX EGC scrubber and EGR	OPEX per year Fuel, EGR and EGC scrubber (SW)			Payback time
27MW	6000h/year		Ref. No EGC	OPEX (3%S)	Saving per year	
System	ECA share	Mio $	Mio $	Mio $	Mio $	Years
Combined	0% ECA	6.20	19.71	16.41	3.29	1.9
	20% ECA	6.20	20.74	16.61	4.12	1.5
	100% ECA	6.20	24.86	17.43	7.43	0.8
Reduced	0% ECA	5.30	19.71	16.63	3.08	1.7
	20% ECA	5.30	20.74	16.79	3.95	1.3
	100% ECA	5.30	24.86	17.43	7.43	0.7

Payback period and other options:

In the case of scrubbers, which are regarded as the most feasible solution amongst the four options, the focus is on the payback period, or ROI (Return on Investment) based on the current oil price and the oil consumption of the ship. Even the same vessel can be affected by the trading route and operating method. Table 3 shows an example of calculating the payback period. The calculation of the payback period depends on whether the view of the oil market is pessimistic or optimistic, and there are considerable differences depending on the opinion of any party, such as the manufacturer of the scrubber and the classification. It depends on the type of scrubber as well, but it is generally considered to be around two years. Even considering the unpredictable oil price, ship owners still can expect safe operation as well as economic operation if they were to operate the scrubbers from 2 years after installing the scrubber.

[4] Reduction of SO2, NOx and Particulate Matters from Ships with Diesel Engines.

In order to do a thorough comparative analysis between the option of installing scrubber system and another option of using low sulphur oxide fuel, there are many variables that cannot be overlooked, in particular, there are unexpected factors that may originate in the four industries from 2020 – scrubber manufacturers, refinery company, blending solution company and engine manufacturer. It is therefore, very hard to predict how these industries will respond to uncertainty while complying with the regulatory regime as discussed in the first section of this paper.

Refinery companies need to change its existing production system to low sulphur oxide fuel, which is likely to take more than five years. In this scenario of an increase in the price of low sulphur fuel, then it is likely that payback period for the scrubber systems can even be reduced to just one year. Accordingly, the installation of the scrubber has additional advantages.

As discussed earlier, the option of Blending solution is unreliable and currently not good enough to be regulatory compliant. Considering the current situation with the refineries, using a low sulphur fuel is a significant risk as well. Since 2020, it is expected that the new scrubber system will be installed on the remaining 4,000 or more vessels to satisfy the IMO regulation until 2026. Clarkson estimates that approximately 6,000 vessels will be equipped with scrubbers until 2026. Based on Clarkson's announcement data, estimates retrofit markets will be around 600 ships per year based on new shipbuilding volume.

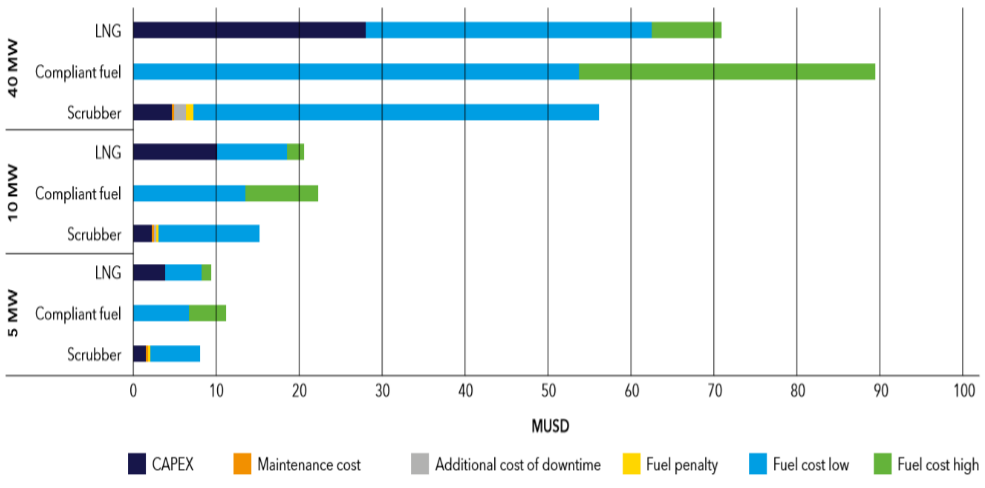


Figure 6: Comparative analysis of different modes in graphical form[5]

[5] Maritime Global Sulphur Cap 2020, Compliance options and implications for shipping – focus on scrubbers - Extended and updated in 2018. DNV GL, 2018.

<Accumulated costs over a period of five years at a 6% discount rate>

Scrubber systems will increase the ship's fuel consumption by approximately 2%. Downtime of the scrubber systems will introduce a cost for running these compliant fuels. Installation of scrubber system will be needed, and accordingly, it will increase the maintenance cost (more for closed loop scrubber systems). For closed loop systems, there will be an additional cost associated with alkali bunkering and sludge disposal system. It is expected that there will be an increase in demand for a Hybrid type scrubber system, which can not only avoid inconvenience due to the limitation of the operating area, but also can operate at a low cost.

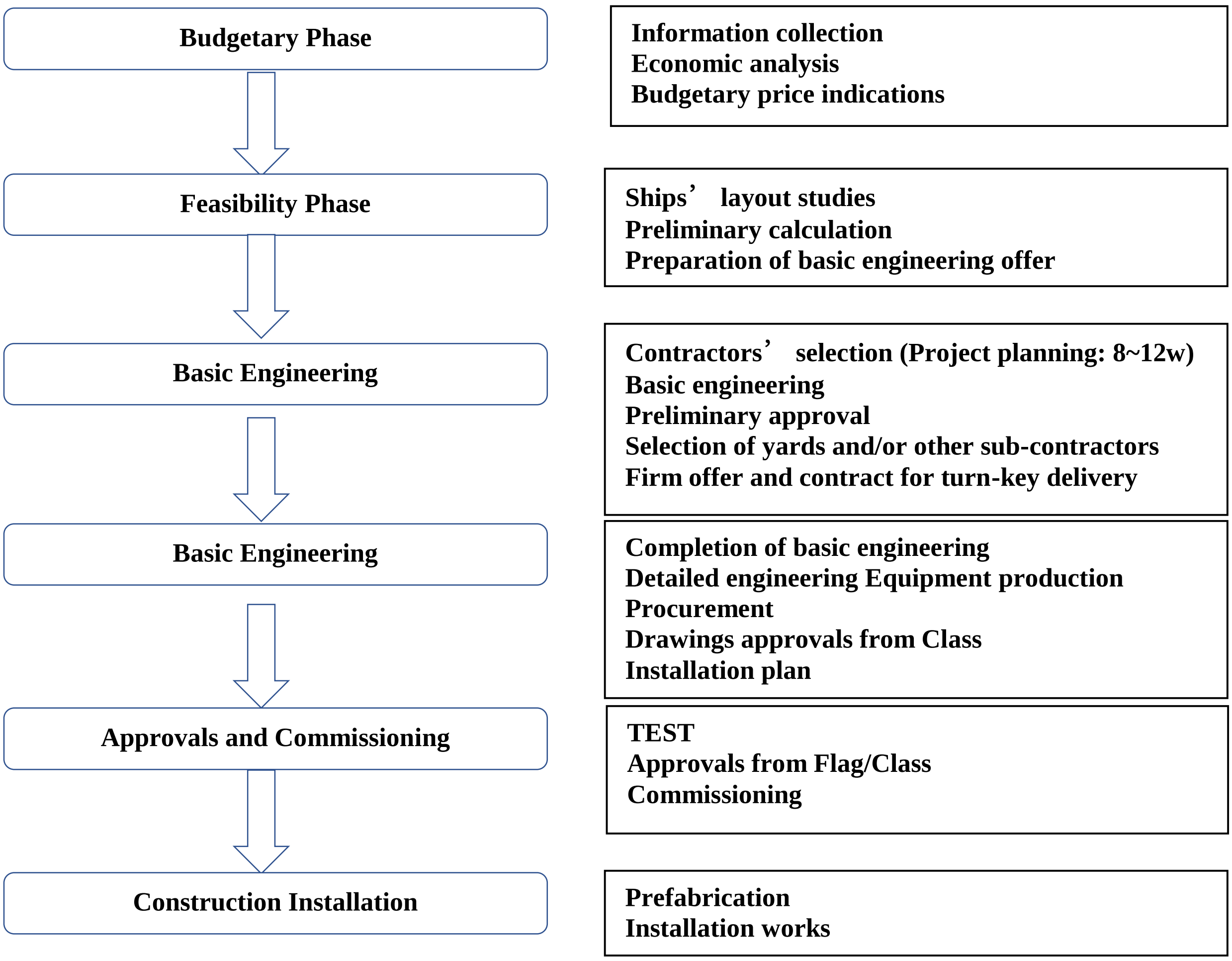


Figure-7: Scrubber Product Value chain

The Preparations and Procedures in context of Scrubber:

To design a scrubber system, it needs to fulfil the strict regulatory environment, in particular, the various geographical areas of operation of the ships. Sufficient information must be provided to installers of such as scrubber system such as fuel sulphur levels, the alkalinity of the seawater, any special conditions in which the ship would be operating in. The scrubber itself has its piping and cabling next to that, there is the heat exchanger, the separator, tanks, pumps, frequency converters, cabinets.

The size of the scrubber is determined by the amount of exhaust gas, and the shape of the scrubber could be different depending on the manufacturer of such scrubber systems. In general, competitiveness of the scrubber system is judged, when it has the optimum design with less installation space and low power consumption while satisfying the required performance expected on the ships. Most of all, it must be regulatory compliant. Ship owners and other stakeholders should request that these specific conditions, such as smaller scrubber size, washing water consumption, and power requirement be fully taken into account to achieve the goal of optimized scrubber equipment installation. U type and I type are typical, and the technique of processing the gas inside the scrubber is different. In the case of a retrofit, weight and footprint are important factors, which is an additional consideration of the ship's characteristics. A general scrubber configuration is as follows:

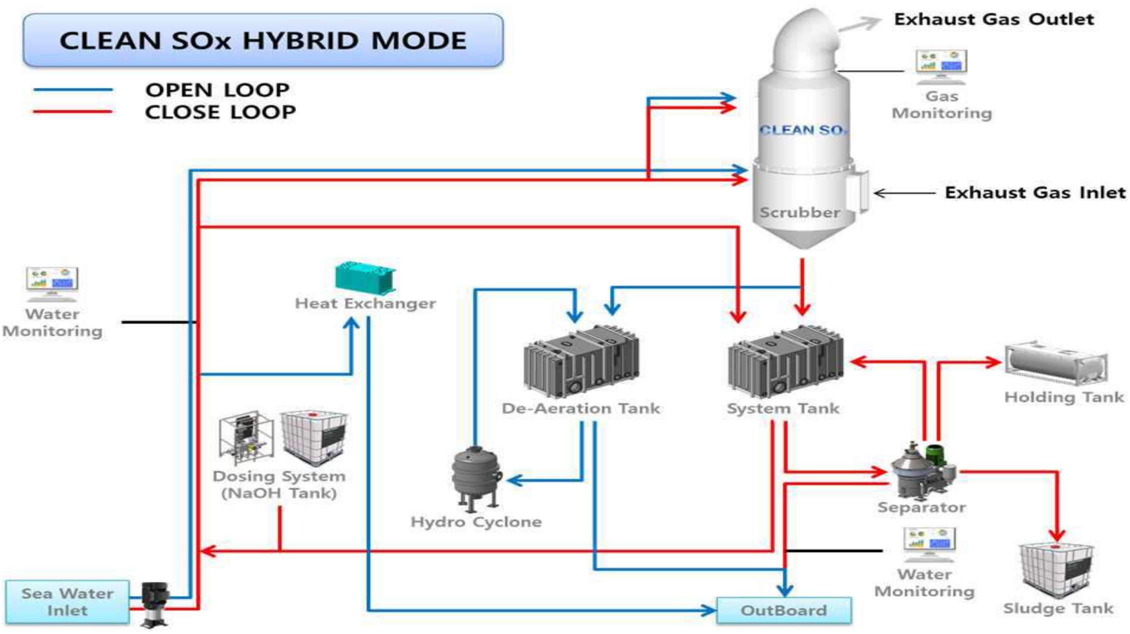


Figure-8: Overview of installation process by marine stellar

- After months of planning, the parts, pipes, and housings were prefabricated and delivered to the shipyard.

- Removal and repositioning of existing equipment began simultaneously at several places on board the ship.
- The various modifications that were required on board took almost three weeks.
- There were new walkways, handrails as well as maintenance platforms.
- Space was created for the new equipment.
- Then once it was installed, the testing was carried out as to whether the equipment was working, the installation was working, and importantly whether the results were within the IMO legislation.

6. CONSIDERATIONS FOR EGCS INSTALLATION:

Positioning and Structure of Scrubbers in engine room:

SOx scrubber equipment does not have any special hazards, so it can be installed inside or outside the engine room depending on space availability. In the case of retrofit, one can also create a separate compartment if one does not have proper space. In this case, prevention of freezing of equipment and requirements for pipelines and cables through engine compartment bulkheads/decks should be considered.

For all these cases, it should be ensured that sufficient space is available for operation and maintenance. As well as ensuring space, the gross tonnage of the ship will be increased. Stability is also taken into consideration because the center of gravity of the vessel changes depending on the location of the SOx scrubber installation. The lower part of the place where the scrubber is installed should be adequately reinforced; the issue of vibration and noise should as well be considered. *I* type installations have fewer footprints than the *U* type, although stability should be considered carefully as there is a simultaneous increase in vertical length.

If the position of the end of the exhaust pipe were to be changed, the exhaust gas should not be reintroduced into the accommodation area. In particular, the exhaust gas part of high temperature should be heat-sealed to avoid fire hazard for safety at sea.

Where the engine room boundary is extended adjacent to the container cargo area, the isolation requirements that are required for the loading of dangerous goods shall be considered as met.

From the viewpoint of installation of such systems, it is important to note that securing of space is often restricted depending on the condition of the vessel, and in the case of a retrofit, it is not easy to satisfy various demands of the owner or the operator.

Power Load:

The additional power required to operate the scrubber must be analyzed. The load ratio of the sea-going merchant ship should be considered and how it is affected by the sum of the power of the scrubber. Should such a system be selected, it is important that the total power should not exceed 90% of generator capacity. If it were to exceed 90%, an additional generator should be installed.

Corrosion of Exhaust and Cleaning Water:

The ship is equipped with main engines, auxiliary engines, boilers, and so forth. Gas is exhausted from the connected exhaust lines from each of these pieces of equipment. Accordingly, the exhaust pipe of various devices is connected with a single scrubber to exhaust the gas; that is, the multi-stream is installed. Therefore, the maximum emission of exhaust gases from all such equipment must be considered. The scrubber increases the back pressure of the exhaust gas of the engine and can additionally affect the performance of the engine, and that can in addition affect the NOx emission limit. When installing the scrubber with the multi-Stream method, there is a need for measures that are required to ease the flow by installing a separate exhaust fan to lower the back pressure.

This is one of the complex parts of the scrubber technology that should be considered. The choice of equipment with a reliable technology is, therefore, paramount in this respect as it can directly affect the operation of marine engines of the ships.

Sulphuric acid in this altered spray state, which has become strongly acidic by sprayed seawater, has the potential to cause severe corrosion on top of the scrubber. Additionally, the inside of the wash-water discharge pipeline is strongly acidic and is therefore installed under the water surface of the engine room to prevent the wash water from being reabsorbed through the other suction pipes of the engine room such as sea chest, *etc*. It is done to prevent excessive corrosion to pipelines and connections. Since the scrubber body and the connected pipeline are large and long, the maintenance of the pipeline affects the performance of the scrubber device itself, and further affects the operation cost of the device after installation. Therefore, in the choice of the scrubber, the material from which the scrubber body and pipeline are manufactured is an important consideration because it affects the operations of the scrubber systems in long-term and in doing so provides required stability. The cost of materials and parts of any scrubber systems roughly accounts for around 40% of the total equipment price. It is to be appreciated that there is a considerable difference in the durability depending on the material or the composition of the material.

7. CONCLUSION:

Due to the difficulties in forecasting the market for oil that can comply with the new regulatory regime along with the fact that work is still in progress for other technologies, which may be in compliance with the regulatory regime in the near future, it is observed in the maritime sector that many ship owners'/ ship managers are moving rapidly to the scrubber market. The feasibility studies carried out in this part along with the practical analysis of the scrubber system including the costs could assist the stakeholders in reaching the decision.

Depending on stakeholders, there are different viewpoints, for example, from manufacturers of engines, manufacturers of scrubber systems, shipbuilders, class societies, bunker companies, Port authorities, oil refineries and so forth. The authors agree that such views and opinions on the scrubber systems are rather varied and frankly, at times somewhat contradictory. However, considering the breakthrough in relevant technology at this point of time, the characteristics of the oil market and difficulties associated with changing the existing bunker lines on board the ships, it is the authors' view that the ship owners cannot delay the selection of the scrubber system for their ships.

However, since a relatively higher initial investment that is required to install scrubber systems, it is necessary for these stakeholders to make a reasonable and effective choice while taking into account the size and age of the ships, its trading areas and so forth. Particularly, durable materials should be selected for stable and long-term operation, and high-level of engineering and yard techniques should be introduced to facilitate pipeline maintenance. In the authors' view, no doubt the installation and operation of the correct scrubber systems will greatly contribute to and enhance the operations for ship owners and operators and other stakeholders.

The expertise of engineers and commercial stakeholders is only going to increase in the future in relation to scrubber systems. The expertise should also in the authors' view keep pace with the rapidly changing expectations of societies and ensuing changes in the regulatory regimes. It seems only constant that stand out is the rapidly changing regulatory regime.

ANNEX I[6]:

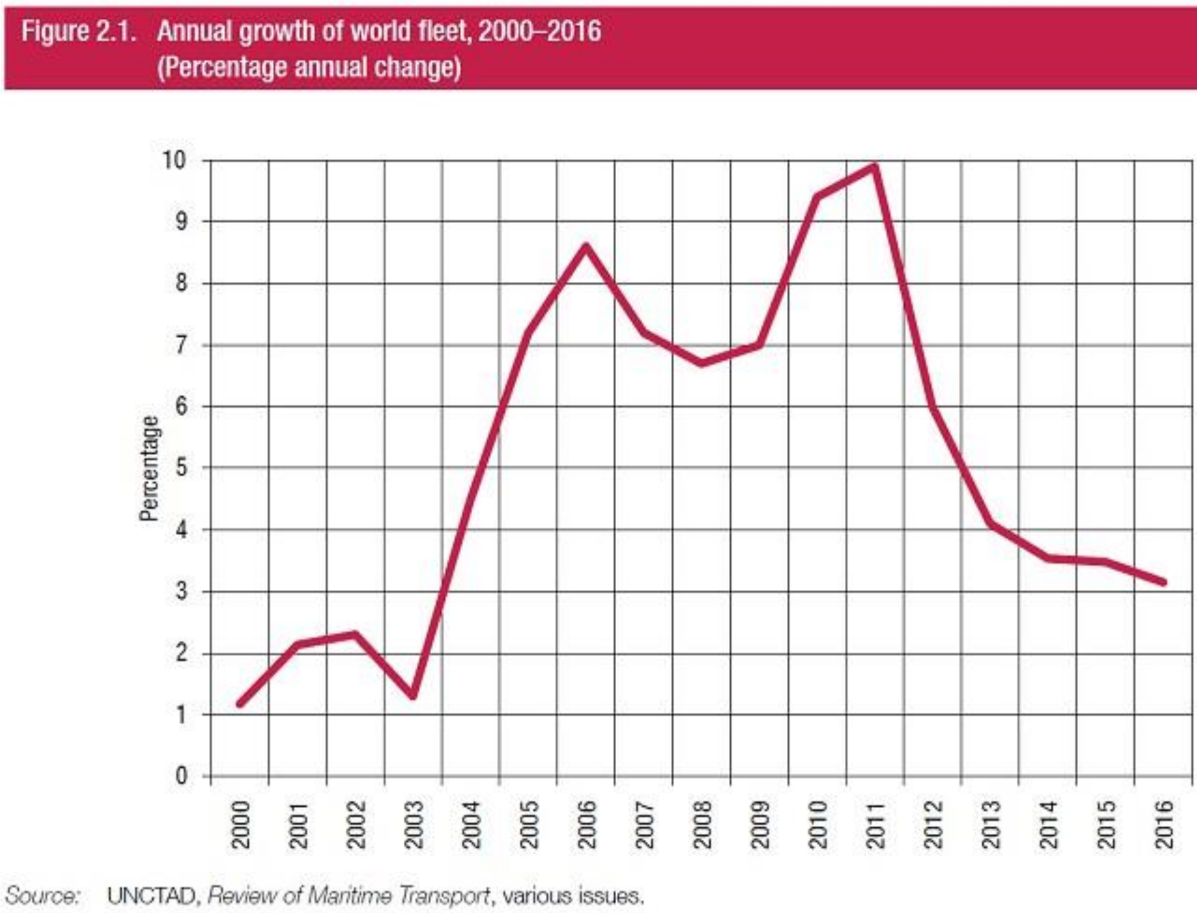


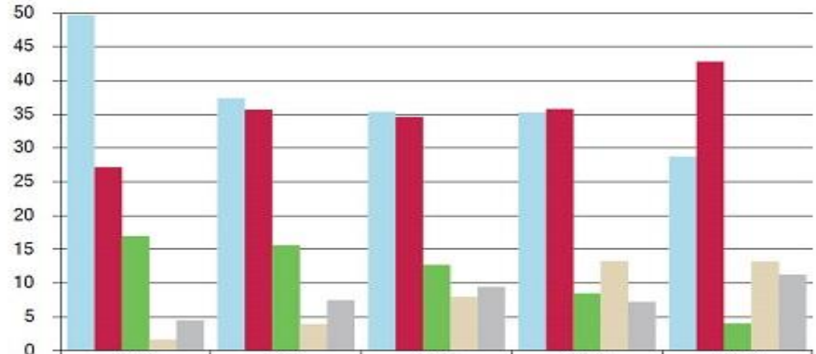
Figure 9: Annual Growth of Fleet rate (2000-2106)

[6] https://www.maritime-executive.com/article/the-global-fleet-revealed#gs.iDswPq8, accessed on 18 July 2018, accessed on 18 July 2018.

Table 4 -: Overview of Emission Areas

Annex VI: Prevention of air pollution by ships (Emission Control Areas)				
	Emission Control Areas	**Adopted By**	**Date of Entry in Force**	**In effect from**
1	Baltic Sea (SOx) (NOx)	26-Sep-1997 07-Jul-2017	19-May-2005 01-Jan-2019	19-May-2006 01-Jan-2021 A ship constructed on or after 1 January 2021 and is operating in these emission control areas shall comply with NOX Tier III standards set forth in regulation 13.5 of MARPOL Annex VI.
2	North Sea (SOx) (NOx)	22-Jul-2005 07-Jul-2017	22-Nov-2006 01-Jan-2019	22-Nov-2007 01-Jan-2021 A ship constructed on or after 1 January 2021 and is operating in these emission control areas shall comply with NOX Tier III standards set forth in regulation 13.5 of MARPOL Annex VI.
3	North American ECA (SOx and PM) (NOx)	26-Mar-2010	01-Aug-2011	01-Aug-2012 01-Jan-2016 A ship constructed on or after 1 January 2016 and is operating in these emission control areas shall comply with NOx Tier III standards set forth in regulation 13.5 of MARPOL Annex VI.
4	United States Caribbean Sea ECA (SOx and PM) (NOx)	26-Jul-2011	01-Jan-2013	01-Jan-2014 01-Jan-2016 A ship constructed on or after 1 January 2016 and is operating in these emission control areas shall comply with NOx Tier III standards set forth in regulation 13.5 of MARPOL Annex VI.

Figure 2.2. World fleet by principal vessel type, 1980–2017
(Percentage share of dead-weight tonnage)



	1980	1990	2000	2010	2017
Oil tankers	49.7	37.4	35.4	35.3	28.7
Dry bulk carriers	27.2	35.6	34.6	35.8	42.8
General cargo ships	17.0	15.6	12.7	8.5	4.0
Container ships	1.6	3.9	8.0	13.3	13.2
Other	4.5	7.5	9.4	7.2	11.3

Sources: UNCTAD secretariat calculations, based on data from Clarksons Research and the *Review of Maritime Transport*, various issues.
Note: All propelled seagoing merchant vessels of 100 gross tons and above, not including inland waterway vessels, fishing vessels, military vessels, yachts and offshore fixed and mobile platforms and barges (with the exception of floating production, storage and offloading units, and drillships); beginning-of-year figures.

Figure 10: Fleet Types – 1980-2017

ANNEX II - Emission Control Areas in a tabular form that were designated pursuant to MARPOL VI and subsequent amendments are as follows:

REFERENCES

ABS Publications, ABS Advisory on Exhaust Gas Scrubber System, July 2018.

Clarkson Research Services Ltd, SOx Scrubber Payback Analysis, 2017.

Dd https://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf, accessed on 8 January 2019.

DNV GL, Scrubber retrofit Meeting the Global Sulphur Cap 2020, 2018.

DNV GL, Maritime Global Sulphur Cap 2020- Extended and Updated, Compliance options and implications for shipping - focus on Scrubbers., 2018.

Eelco den Boer, Maarten 't Hoen, Scrubbers - An economic and ecological assessment, Delft, CE Delft, March 2015.

http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx, accessed from 18th July 2018- until 31 January 2019.

http://www.imo.org/en/OurWork/Environment/SpecialAreasUnderMARPOL/Pages/Default.aspx, accessed on 18 July, 2018

https://unctad.org/en/PublicationsLibrary/rmt2016_en.pdf, accessed on 3 January 2019 https://www.maritime-executive.com/article/the-global-fleet-revealed, accessed on 3 January 2019.

https://sqemarine.com/marpol-annex-vi-cic-best-practice-guide/, accessed on 5 January 2019.

https://www.asef2015.com/asef2007/PDF/2-8.%20Air%20pollution%20by%20Mr.%20Kim%28Korea%29.PDF, accessed on 16 February 2019.

https://www2.mst.dk/Udgiv/publications/2014/03/978-87-93026-57-5.pdf, accessed on 30 January 2019.

IMO Publications, IMO IC664E MARPOL Annex VI and NTC 2008, 2017 Edition.

IMO Publications, IMO IE520E, MARPOL Consolidated Edition 2017 Books.

Jens Peter Hansen, Johan Kaltoft, Flemming Bak, Jens Gørtz, Michael Pedersen, Chris Underwood, Reduction of SO2, NOx and Particulate Matters from Ships with Diesel Engine, Miljøstyrelsen, 2014.

Korean Register of Shipping, Exhaust Gas Cleaning Systems Technical Information, 2018.

Man Diesel and Turbo, Guidelines for Operation On Fuels with Less Than 0.1% Sulphur, Pasi Pajula, Wärtsilä Finland, Retrofitting Scrubber and LNG technologies to existing ships, Environment Solutions Marchain Green Propulsion Workshop 2012, Klaipeda, Lithuania.

Stavros Hatzigrigoris, Paraschos Liadis, Scrubber Technologies (Open-closed or Hybrid, Single or Multi-stream) Will an investment in Scrubbers pay back? 14 November 2017.

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ENHANCING FLEET PERFORMANCE MANAGEMENT USING BIG DATA ANALYTICS

Kaushik Seal

Abstract

The Maritime Industry is looking to explore new business models through digitalization. Companies are increasingly recognizing the need to overcome data quality issues and manage the ownership, security, sharing and use of big data. These data analytics are encouraging fleet management and commercial operation to innovate and explore opportunities for driving cost efficiencies and new revenue streams through digitalization.

Key words: Big data, Data analytics, Digitalization in shipping

1. THE CRUX:

Every maritime asset, every maritime system is producing a wealth of data. The challenge is to unlock that data, to get it out of its silo and turn it into a productive asset in its own right. But how can openness be balanced with quality, security and control?

The maritime industry is looking to boost their profitability and explore new business models through digitalization. However, companies are increasingly recognizing the need to overcome data quality issues and manage the ownership, security, sharing and use of data. To facilitate friction-less connections between different industry players, domain experts and data scientists, DNV GL has launched an industry data platform. As an independent technical assurance and classification/ verification company, DNV GL already manages an enormous amount of asset and industry data on behalf of many different maritime stakeholders and data owners. By combining our asset data and other data with your data we can unlock data silos and provide a friction-less, quality assured data market place that releases the value in data. Owing to their potential for a major transformation and disruption of current businesses, digitalization and advanced data analytics are among the top priorities for all industries, including shipping. While shipping has access to a greater volume of data than ever before, it faces challenges assessing its potential. This is mainly due to data arriving from disparate streams, in dissimilar formats and at varying speeds and quality. In light of these challenges, companies are increasingly building their strategies around digitalization opportunities. They are encouraging operation, fleet management and commercial departments Creating value from data in shipping DNV GL is trying to innovate and explore opportunities for driving cost efficiencies and new revenue streams through digitalization.

For the ship owner or manager of ships, staying competitive is paramount. A survey conducted by DNV GL in 2016 indicates that industry leaders believe a 10% to 25% reduction in total vessel OPEX (including fuel costs) is possible through broad efforts in operations, technical management and considering interfaces to commercial activities. Customers have identified several measures leading to cost reductions. These include thorough improvements of all fleet management activities, such as voyage execution, as well as engine, system and hull performance, in addition to the commercial side of the business. They recognize that in so doing, they will need to embrace the full variety of digital solutions. The term “digital solutions” in this context may factor in everything from auto logging systems to state-of-the-art, sophisticated logistics planning systems, as well as advanced analytics of data and the respective tools. In our opinion, the future will be guided by six technologies which will impact vessel operations; they are:

1) Sensors and Internet of Things (IoT)
2) Connectivity
3) Handheld devices (mobiles and tablets)
4) Big Data and analytics
5) Platforms and
6) Cloud computing.

Vessels built or designed today have more sensors and better communication systems than the vessels operating today. Components may come fully equipped with sensors from the manufacturer. We expect this trend to only increase with time. Key questions for a new unit will be: what are the sensors monitoring? How can the data they provide be used? With fully or partially sensor-equipped components and systems, monitoring and simulations can be taken to the next level. Data logged from various equipment can already today be put into models simulating system behaviour. This data logging will lead to a rapid increase in the statistical learning curve for maritime equipment, including failure events. Machine-learning algorithms will gradually become available for this purpose. Proper use of data contributes with substantial value towards more efficient operations, but prerequisites are effective tools and analytics. With regulation becoming more data centric, forward looking data strategies need to consider efficient compliance with these in the context of other, value creation activities. There are a few issues to consider when planning for how to create value from data:

1) **Collect the right data**: Voyage, engine and environmental data from a vessel has value when it is analyzed and presented in a format that matches the maturity level of the organization. There is no need to collect an excessive amount of data unless you can make use of it. Or if the data quality later turns out to be insufficient for sensible use. When defining data collection scope, start with defining what you want to achieve with it. For example, for basic compliance or for making decision to save fuel and Opex, or as inputs for a strategy process.
2) **Integrating different data sources**: A system should be able to integrate and present data from different on-board sources to avoid that this must be done manually. A typical situation aboard many vessels today is that some information is collected manually through 'noon' reports, engine logbook, environmental reports, while other data may be collected automatically through sensors. For proper fleet performance management, the different data sources should be combined onto one platform or portal. Solutions exist in the market today that deliver this functionality.
3) **Complement with industry data**: Some commercially available systems enrich vessel data with industry data to enhance understanding of performance, for example by using satellite wind data, sea state data, vessel position data (AIS), fuel quality, fuel price information.
4) **KPI monitoring**: Data should be presented in a format that enables monitoring of key performance indicators on vessel/fleet level, whether this is technical, operational, environmental, safety or commercial.
5) **Benchmarking performance**: A visualization system should enable benchmarking against suitable baselines and reference lines. *E.g.* how is my vessel fuel performance compared to last quarter (own benchmark), compared to fleet average (fleet benchmark) or compared to my peers in the market (industry benchmark).
6) **Sharing of data within the company**: There are different users of the same data within one company (technical, operations, commercial, management) that may have different needs. Dashboards can visualize relevant information related to safety and compliance records, as well as technical and financial performance and statistics, customized to the needs of the different users. An effective data visualization system must be flexible in how it presents data to meet these needs, *e.g.* 'Management Dashboard', 'Operational Dashboard', 'Technical Dashboard'.
7) **Data output and integration with other systems**: A flexible system for data analysis and presentation should be able to link to other in-house systems, *i.e.* link between technical

performance systems and in-house commercial BI (Business Intelligence) systems. BI systems provide features such as calculations and analysis. To make the right decisions, it is key that data is provided in a format that enables transformation into useful knowledge in the BI system. Given the profound shift towards mobile user interfaces and given the fact that staff of ship owners or managers spend a substantial amount of time travelling, mobile access to data and insights will increasingly be demanded. Considering the limited space on screens of smartphones and similar devices, content and presentation of data and insights have to be completely re-thought, eventually resulting into a “mobile-first” approach to all user interfaces. Most systems are not prepared for this today, respective strategies and concepts need to be developed.

8) **Commercial off-the-Shelf (COTS) vs Customer Specific Systems**: A customer specific system for handling and visualization of data can be designed to meet the exact company needs. At the same time this can be complex and expensive to build and maintain over time and will create challenges in the future when requirements or underlying technologies change. A commercially available system may be less flexible in detail design, but often has more advanced functionality that has been proven and enhanced, often through the experiences of hundreds of users. Development, new releases and maintenance are taken care of by the system provider, and bugs are removed continuously. There are commercial decisions around building a system vs. using one as a service. Plus, every owner / manager needs to decide if a bespoke system will create a sufficient competitive advantage or if the resources would be better invested in monitoring the insights generated through a commercially procured system and managing the resulting improvement activities.

Digital technology is not new to the shipping industry. However, following major advances in sensor technology and data storage capabilities, the industry is now faced with new opportunities for utilizing data, arriving from all parts of the value chain. The ability to connect and analyze these disparate data streams has not kept up with the pace at which the sheer amount and complexity of data has increased. This growth provides new opportunities for data to play a larger role in many areas like integrating operations across assets and system barriers, improving efficiency of operations, identifying new business opportunities and optimizing commercial performance. Things are moving fast in the digital arena, and we need to accept that today’s perspective might soon be rendered obsolete.

2. CONCLUSION:

The exact next steps are still not fully evident, but the pressures to reduce costs, increase efficiency and improve safety will play a dominant role in driving speedy implementations of new digital solutions. Players in the shipping industry may benefit from opportunities for efficiency gains and cost reductions if it can better address the data that are already collected today and continue to explore, utilize and share new sources of information. And while different companies and players within the industry are at varying stages of digital adoption a few early adopters are emerging. Those at the early stages of maturity are increasingly facing the challenges and opportunities and are taking steps to understand the implications to their daily businesses. The exact next steps are still not evident, but the pressures to reduce costs, increase efficiency and improve safety will play a dominant role in driving speedy implementation of new digital solutions. Through collaboration and investment on innovation, the industry can start to overcome the challenge of extracting value from data. To replicate a sharing paradigm as seen in other industries, more trust and assurance in how the data is managed will be required. Trusted partners who can provide the required infrastructure, secure data quality and access protection will be important building blocks to unlocking the gains possible in a collaborative, data centric future. The digital transformation is challenging the traditional business models employed in the shipping industry, and will introduce new forms of interaction between stakeholders. Players who are quick to embrace the transition will gain a unique competitive advantage as they gain better control of their operations and keep costs down in an increasingly demanding industry."

REFERENCES:

PRACTICAL GUIDE on *Creating Value from Data in Shipping. A DNV GL Maritime Publication*, 2017

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CAUGHT IN NUMBERS, LOST IN FOCUS

What it means to manage safety in global shipping

Dr Nippin Anand

Abstract

Study after study has been conducted on safety management without ever engaging critically with the term safety or examining how it became one with the science of management.

Producing comprehensive accounts of all 'unharmed' and 'uninjured' events is mundane and resource-intensive. Instead, the alternative approach is to examine harm and injuries both potential and actual. What we get is 'unsafety management'.

If we regard management as a question of measure and control in order to allocate material and manpower, it follows that managing safety is a question of measuring and controlling unsafe events. But this approach has become problematic at all levels, from board room to engine room.

Key words: Safety Management, Safety KPIs, Safety compliance

1. MIXED MESSAGES:

In April 2010, the fire and explosion on-board the *Deepwater Horizon* killed 11 people and resulted in the most significant oil spill in the history of the United States. The investigation brought to light a number of organisational factors, of which the role of senior management in motivating the employees was considered of extreme importance. Senior management ambitiously promotes a 'zero accident' culture to its employees through policy statements. This is not a moral or ethical stance; it is the result of intense market competition and insatiable customer demands. A company that experiences and reports accidents is regarded as 'unsafe' and stands much less chance of acquiring further business. Accidents are undesirable for reputational reasons: the positive contribution that maritime transport makes to global economy is far less conspicuous than the negative attention it draws following an accident. So the message from the boardroom is clear – no accidents please!

What is more, along with the utopia of 'zero accidents' comes 'zero defects' and 'zero off-hires'. The intentions are good of course – but intentions become company targets, company targets are internalised in every individual employee's appraisal and all this results in mixed messages. ‘Maintain safe speed – but don’t arrive late,’ or ‘Safety first – you know what I mean!’

2. MEASURING SAFETY:

We are often told that that which cannot be measured cannot be managed. The problem with safety is not how it is managed but instead how it is measured. In general, the role of company safety departments is twofold. They are expected to ensure compliance with rules, regulations and company procedures, and at the same time to manage reporting and analysis of occupational (but not technical) health and safety issues. This is reflected all too often in recruitment adverts and job descriptions for HSEQ personnel. This confusion between quality and occupational safety, and the divorce of occupational safety from technical safety can lead to issues in both measuring and managing safety.

3. OCCUPATIONAL HEALTH AND SAFETY (OHS) INDICATORS:

OHSAS 18001 defines occupational health and safety as ‘All of the factors and conditions that affect or could affect the health and safety in the workplace’. In practice, OHS is measured in terms of ill health, minor incidents, and incidents resulting in restricted work with more serious occurrences recorded as lost time incidents. Events of this type are frequent, which allows companies to study patterns and trends in establishing safety. The world of statistics thrives on input and vessels are encouraged to report every single incident experienced on-board. But if the safety departments are not adequately resourced to deal with these reports, the quality and thoroughness of analysis is compromised. Several studies have found that the number of incidents reported is not always a genuine reflection of safety.

In addition, there is a degree of misrepresentation in reporting incidents. For a company operating a handful of vessels leased by a reputable charterer, a serious incident might mean closing down business and declaring bankruptcy. For a Master it would mean endless queries from every possible stakeholder and ‘gruesome paperwork’. But pragmatic problems can also be met with pragmatic solutions. And this is simple on a vessel which is mobile, and far away from ‘head office’. Simply report incidents selectively – depending on whether the severity of the incident makes it impossible not to report, or whether the consequences of the incident are not worthy of the attention and ‘paperwork’ they demand. How else is it possible for a vessel manned by minimum crews stretched to the limit, operating in harsh weather conditions and tight port schedules to maintain 300 days free of lost time incidents (LTI)? And if this is not enough, consecutive years are expected to demonstrate continuous improvements in LTIs.

4. OHSA AND TECHNICAL SAFETY:

The methodology for establishing trends in high frequency incidents is based on examining reactive indicators (or lagging indicators) that could lead to serious accidents. This methodology was first established by Herbert Heinrich in the year 1931. According to Heinrich, most accidents in the workplace shared a common root cause, and major injuries could be prevented by understanding and addressing the common root causes generally linked with workers' behaviour. For every accident that caused a major injury, Heinrich found there were 29 accidents that caused minor injuries and 300 accidents that caused no injury at all. Contemporary literature uses terms such as minor injuries, restricted work injuries (RTI), and lost time incidents (LTIs) to explain Heinrich's Law. But the application of Heinrich's Law in today's world is questionable.

It is difficult to establish trends for major accidents with the potential for serious injuries or multiple fatalities, such as fire in machinery spaces, hull failure, explosion, *etc*. A vessel may not have had a fire in machinery spaces in five years, and all of a sudden experience two incidents in the subsequent year. In such cases, technical safety (or process safety) is used as a measure of safety management. Technical safety is contingent upon design intent, engineering modifications, maintenance management, *etc*. Hull structure integrity, maintenance of pressurised fuel lines, operational readiness of fire detection and protection systems, *etc*. are all examples of technical safety.

It is here that the application of Heinrich's Law becomes weak. For instance, the use of incorrect personal protective equipment (PPE) may not be of much assistance if the pressure relief valve on a boiler becomes inoperative. Neither does Heinrich's Law explain the underlying reason for loss of life resulting from a short circuit in the electrical switchboard if the safety awareness of engineers in the past has raised no concern.

Substandard design, overdue maintenance or critical spare parts awaiting replacement are all things that require commitment from the senior management; they are not a reflection of behavioral problems at the grassroots. The problem is largely the result of a tenuous relationship between OHS and technical safety. The use of OHS incident data alone does not help in understanding and preventing serious accidents from occurring.

But this is not to say that Heinrich's Law does not apply to technical safety. Incident reports such as 'slight leakage in lubricating oil pump', 'small crack in a double bottom tank', 'minor engineering modifications without approval' if unnoticed may lead to serious outcomes. But all this requires seriously questioning and analysing the nature of incidents, rather than just counting the number of reports. Another line of inquiry is the absence of technical safety from the role of safety departments in many companies. In many ways, the two departments within the same company can operate in isolation. This is evident from the clear functional separation between safety management and maintenance management. In general, the technical department is left to measure its own (safety) performance with little intervention from the safety department. And where technical function reports to operations (rather than directly to senior management), technical excellence can become a matter of reducing risks to 'as low as reasonably practicable'.

5. SAFETY VERSUS QUALITY:

The original quality assurance standard, BSI 5750, which has since been superseded by the ISO 9000 series, was meant to provide 'certified reliability' to firms looking to expand business in emerging economies. Here, the term 'quality' does not refer to improvement in product or processes; it is about consistency in managing operations and meeting customer requirements. Quality standards have served well as a set of generic management standards aimed at limiting the liability and insurance expenses of companies.

The ISM Code borrows its methodology and structure from the ISO quality standards, but is based around safety and environmental protection, rather than customer needs. However successful this approach has been, it has also proved a major source of contention. So intense is the relationship between quality and safety that companies have difficulties distinguishing between quality and safety indicators. It is in the interest of companies to avoid accidents in the same way as it is in their interests not to experience downtime and off hire time. Maintenance of safety equipment is critical not least for safety but also for operations. No customer is interested in hiring a substandard vessel with questionable maintenance standards.

The problem is that quality as we understand it today is about liability management. It is not always appropriate to manage safety in the same way. Quality objectives can easily get confused with safety especially when HSEQ falls within the same remit. This is quite a challenge when the same people who work in the safety department also end up working across the quality, environment and health departments. Take the example of an inoperative watertight door in the engine room that in the ship owner's understanding may lead to vessel detention by port state control. Should this be treated as a quality issue, resulting in a delay in port which may have severe reputational and commercial implications, or as a threat to vessel and crew safety? Both assumptions are valid, but the way the incident is viewed may affect the way that it is handled. If the matter is treated as a quality issue, the first reaction will be to notify the flag state administration, classification society, insurance company and in general demonstrate due diligence. On the other hand, if it is seen as a safety issue, the immediate response is to examine the technical and operational risk of a defective watertight door, the potential risk of progressive flooding through compartments in the worst case of hull failure, loss of power due to flooding in machinery spaces, the impact on damage stability, and the assessment of crew competence in handling difficult situations.

The management of safety can vary significantly from adopting minimum compliance to a genuine concern for safety of life and property. But even compliance as a measure of safety is questionable.

6. COMPLIANCE IN SAFETY MANAGEMENT:

Compliance (in terms of whether shipboard tasks and operations meet the standards required) can be assessed against company procedures and/or rules and regulations. Where deviations are found, non-conformances are issued and become fundamental to measuring and managing safety. But this approach has problems at many levels. Procedures are rarely written to cover every conceivable situation, even for a single operation. Procedures written by a Norwegian operator and assessed by a Polish auditor may not always be easily understood by a Russian master. Where procedures are written without crew input, there is a good chance that not following procedures may be a safer choice. Even a simple four step procedure for release of the CO2 system can be interpreted in various ways. If not correctly written, the procedure might miss out critical steps such as carrying out a head count of crew members or shutting off the dampers before releasing the gas. Similarly, documenting a non-conformance as a result of not complying with a plan or process (for example taking short cuts in passage plans) may completely miss both the cause and the outcome (for example limited time at hand). In the absence of intelligent analysis, the relationship between non-conformance with procedures and safety is questionable.

Using non-conformance with regulations and conventions as a measure of safety is a matter of equal interest. Maritime regulations and conventions can be very detailed and prescriptive. Further knowledge of relevant technical codes, circulars and special flag state requirements only makes the requirements more complicated. Certain regulations and conventions may also conflict. For example, the security plan when in piracy areas may impede safe access. Ballast water exchange requirements at sea may have implications for vessel safety and stability. Inspectors, surveyors and HSEQ staff, like all human beings, suffer from cognitive limitations. What you seek is what you find but what you find is often what you know. A non-conformance issued against a vessel may be the outcome of preferences, biases, specialist knowledge, past experiences or even social and political agendas. Equally, inspections carried out with detailed checklists by less experienced staff without a genuine appreciation of risk may not be a true measure of safety. Several ships have had non-conformances issued for not segregating garbage in accordance with the MARPOL requirements when the entire port and surrounding communities have been dumping garbage right at the entrance of port. Compliance should therefore be used critically as a measure of safety.

7. RECOMMENDATIONS:

If management requires measuring, then measuring safety requires us to establish reliable indicators of safety and make them work. These indicators can be highly interactive and conflicting. Matters of personal safety may not always mesh smoothly with technical safety. Indicators can be leading (pro-active) and lagging (reactive). Reactive indicators may also be proactive indicators of a serious accident waiting to happen. Therefore, personal injury, failure of equipment, violation of procedures or any other form of reactive indicator, needs thorough analysis that goes beyond simplified statistics and graphs.

Non-conformances as reactive indicators often result in a detailed review of procedures or training of crew, without making sense of why these procedures have become meaningless to those at the operating end. Introducing more detailed procedures will only undermine trust levels and result in even further non-conformances. All this may not necessarily serve the true intent of safety management.

Even more challenging is the monitoring and measuring of proactive indicators, as it is not always easy to envisage incidents that have not occurred. Measuring safety through predicting what may go wrong in the future requires unease and reflection, particularly for practitioners with extensive work experience. It begins with examining what is ‘usual’ and what is ‘normal’ within the company and on-board ship. A minor intake of water in the stern tube, a regular fault alarm on the fire panel and a daily issue of bilges getting flooded are no longer regarded as risks by those serving on-board the vessel. The unusual and abnormal becomes normalised in routine work – until such time as it leads to an undesirable outcome.

For this reason, it is important that not every inspection and ship visit is based on agendas or planned inspections with detailed checklists. Ship visits, especially those from senior staff, should aim to engage with the crew in trying to make sense of everyday work patterns. For those in senior positions, it is also important to develop the ability for humble listening, rather than shutting up the crew by retelling their own experiences and cost saving sagas. Simple questions, such as asking what is the most dangerous job that the crew member performs and how it could be improved, can generate powerful responses. Engage with people at all levels, not only in the comfort of the Master’s and chief engineer’s offices. Companies should not expect fresh perspectives if the same staff visit the same vessels on every occasion. Diversity is a proven source of organisational resilience and safety. Intention is key to measuring and managing safety. The absence of any genuine concern or understanding of safety risks will lead to defensive attitudes that only generate mindless paperwork. More paperwork only exposes more holes in the system, and will eventually lead to embarrassment in the courtroom. Of course there is an easy way out – blame the seafarer!

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DIGITALIZATION OF MARITIME EDUCATION AND TRAINING

Dr (Capt) Suresh Bhardwaj

Abstract

The digitalization push in the maritime operations and education and training in general is invariably influencing the field of Maritime Education and Training as well. However, the excitement with all the buzz and potentials of technology needs to be carefully weighed against its application in safety-critical, skills and competency based domain of shipping operations.

Key words: Digitization, Maritime Education and Training, Competency Based Assessments

1. THE DIGITALIZATION PUSH:

Digitalization in education refers to the use of desktop computers, mobile devices, the Internet, software applications, and other types of digital technology to teach students of all ages. Test-taking using a computer, online universities, e-books, and edutainment are just a few examples of digitalization in education today. The term "digital training solutions" encompasses a much wider choice of training techniques than just self-paced e-learning.

Today, due to accelerating processing speeds, increased memory capacity and the decreasing cost of hardware, computer based training and assessment has made much inroads. The power of hardware and sophistication of software design now allow desktop-based multi-media presentations, simulation exercises and virtual reality solutions to work effectively in individual, local, wide-area and Internet environments. Computers are popular for their ability to rapidly store and recover data, respond to a user interaction, and integrate multi-media applications which can incorporate visual, audio and physical stimulus.

Simulations mimic the real world in computer models. In the context of training, simulations denote any application where the user changes some interactive control and sees the outcome. Often, gamification of training is connected to simulations in digital solutions. There are various maritime applications in simulation-based training, example, computer simulations with suitable graphics can help trainees to learn and retain qualitative relations, *e.g.*, between ship form parameters and stability (Baldauf *et al*. 2018).

Virtual Reality (VR) for us means a computer-generated 3-D space to navigate through, with control devices allowing manipulation, operation, and possibly control of items in this 3-D space.

Augmented Reality (AR) combines real world with overlaid computer-generated images. A typical application is a nautical simulator which combines a real bridge with a simulated outside world. The approach is ideal with scenario-based learning, where a given task in a scenario has to be solved, *e.g.*, handling a rudder failure without causing an accident (Lukas,2010).

So, here we have new training tools, and the demos from vendors are impressive. There is a new-found optimism, a spirit of a new beginning, where we will leave the drab, underfunded old world of classroom training in dull engineering/regulatory topics behind us, and enter a new world of exciting training options, with videos, Virtual Reality, and gaming to make training memorable and fun.

2. THE CAVEAT:

Some educators and technology evangelists amongst us believe that eventually Maritime Education and Training (MET) will be an entirely digital pursuit, fortified by artificial intelligence and virtual reality.

There is a caveat though:

Seafaring is a practical and demanding profession, requiring fast and accurate analysis of situations; and swift, decisive action. Candidates for seafaring jobs are therefore, expected to exhibit a balance of cognitive, affective and psychomotor skills. In addition, in an increasingly complex workplace that ships are getting, seafarers require a high level of teamwork and interpersonal skills in order to function effectively.

If the intention is to replace a well-designed training and exercise session supported by a good trainer with Computer Based Training (CBT) material alone, it should be realised that it is possible to impart a lot of knowledge, but individuals may not be able to put it into practice, due to the lack of tangible and physical environment, the lack of team support, and the lack of the necessary human interaction.

In safety critical industries such as shipping characterised by high-risk workplaces, any changes to training and assessment methodologies must be aimed at enhancing critical skills as opposed to commercial expedience or just fad.

The findings of some early measures suggest that many people might be entering the occupation with questionable qualifications owing to the unreliability of the new assessment methods. Not only is the safety of shipping put at risk, including the safety of individual workers, the cost for ship owners is increased by the need to introduce separate assessment and basic re-training procedures and recruitment level.

Therefore, whilst digitalization has many potential advantages, its design and application, particularly in safety-critical areas like seafaring can be problematic and must be considered carefully (IMO, 2002).

In shipping, the haphazard ways in which digitalization is currently being implemented pose possible dangers to workers' lives and to the environment.

3. DIGITALIZED ASSESSMENTS AND E-EXAMINATIONS:

There is a study commissioned by EMSA (European Maritime Safety Agency) and conducted by SIRC (Seafarers International Research Centre, Cardiff University) in 2009-10 titled CBA in MET (Gekara *et al*, 2011). It revealed that CBA in seafarer's licensing examinations has been mainly driven by three factors; increasing examiner workload, the need for objectivity and consistency and the need to meet growing international demand for officers. It might seem therefore that Maritime Administrations are primarily motivated by cost and practicality as opposed to the pedagogic issues of *validity* (the ability of an assessment to effectively test that which it is intended to), and *reliability* (consistency of testing across a range of instruments, environments, assessors, and time).

There are different aspects of validity in assessment, including *content validity, construct validity, criterion validity, and predictive validity*, all of which describe ways in which various assessment instruments may be employed to achieve robust and meaningful assessment outcomes.

Construct validity refers to the 'degree to which elements of an assessment instrument are relevant to and representative of the targeted construct for a particular assessment purpose'. *Content validity* is how the assessment material relates to the core objectives of the training. *Criterion validity* is the correlation between test results to the expected external behaviour based on predetermined criteria.

An important part of the discussion of validity in competency-based training such as MET relates to *authentic assessment* and *predictive validity*. The proponents of *authentic assessment* have argued that for an assessment to be robust, it must closely simulate the real-life work environment in which candidates are expected to apply their acquired knowledge, skills and competencies. The results of one's test should, therefore be closely *predictive* of candidates' performance in real-life employment situations.

This involves fulfilling all the aspects of *validity.*

So CBA (Computer based Assessment) like MCQ (Multiple Choice Questions) within the safety-critical field of maritime education and training (MET), particularly, in relation to the *summative assessment* (outcomes) of seafarers for licensing purposes is highly inadequate. CBA may be useful in testing basic knowledge recall (which may be promoted by rote learning), but can CBA be usefully applied in relation to the assessment of higher cognitive skills such as *comprehension, application, analysis, synthesis,* and *evaluation*, is highly questionable. And then there are issues like Security and Corruption as well.

Vocational Education and Training assessment is designed to determine the extent to which a trainee has effectively acquired the skills and competencies along with knowledge that is required by the employers. Across a range of occupations, such testing has traditionally comprised a portfolio of practical on-the-job assessments. MET has already in place some good systems prescribed under the STCW (Standards of Training, Certification and Watch-keeping), like the structured training record book that accompanies the mandatory on-board apprenticeship, and laboratory / simulator based courses.

The tests typically based on simulator scenarios are developed by instructors and tested and approved by Maritime Administration examiners. The selection of test scenarios is undertaken by a designated external examiner/invigilator, normally assigned from the Maritime Administration.

On the engine side candidates are tested using simulation scenarios based on any one of the essential engine systems. The engine systems on which training and test scenarios are commonly based include the boiler system, the fresh water generator system, the lubrication oil system, heavy fuel separator and the diesel generator. The assessment essentially requires candidates to 'line-up' (prepare) the system, start it and 'watch-keep' (monitor) its operation throughout the session. Test time typically is about 30 minutes with an equal allocation for preparation. Two engine problems are programmed to occur during the simulation exercise, which candidates have to resolve. Problem resolution is allocated about seven minutes. Candidates lose marks if they delay or fail to solve the assigned problems. Problems are signalled by alarm indicating the location of the problem but not its nature. The task, therefore, includes analysing and determining the cause of the problem and affecting a solution. Scoring utilises a built-in automatic point-deduction programme whereby candidates' marks reduce as the exercise proceeds depending on the speed with which they started the engine, maintained it and problem solved. In instances where the problem set was not critical to the operation of the system, the candidate could move on to the next stage of the test without solving it. In such cases candidates lose 20 points. Where a problem is critical candidates automatically get failed if they are unable to resolve it. The test pass mark is 70%.

Practical assessment for deck officers similarly lasts 30 minutes and covers navigation, manoeuvring, docking, and collision avoidance. Using simulations candidates are required to manoeuvre a vessel under predetermined traffic and weather conditions. They are for instance, required to make sure that the vessel maintains course and speed, stays a certain safe distance from other vessels and the shore and maintains the required safe draft (minimum depth of water).

Like the engine tests, performance is automatically scored on a point-deduction basis: candidates are penalised for mistakes and lost time. Particular errors result in automatic failure, for example, grounding, collision or a failure to complete the 'voyage' within the set time. In order to effectively test candidates' skills a number of traffic distractions are incorporated into test scenarios, for example other vessels approaching and manoeuvring. After 30 minutes the test gets terminated automatically and the test results, including a detailed graphic representation of the route taken by the candidate is printed off and signed by the examiner. The pass mark is 70%.

4. CONCLUSION:

Digital training solutions are more than the (in)famous e-learning. Matter of fact there is a new-found optimism and excitement. But the excitement sooner wanes as we find funding not meeting up to expectations, as some of the technology enabled learning resources can be prohibitively expensive. So also, there is very limited area rendering suitable application. This kind of disappointment is common in technology hype. Many initiatives start by attempting to boil the ocean and not by focusing on something smaller and attainable (Bertram and Plowman, 2019).

There is of course no doubt that we will see digital training solutions on the rise. But we will see classroom training possibly improved by adapting some of the brain-friendly training techniques that come with the new wave of digital training, and thus a lot of blended learning, in various ranges as they address different training needs.

REFERENCES:

Baldauf, M.; Kitada, M.; Mehdi, R.; Dalaklis, D. 2018. E-Navigation, Digitalization and Unmanned Ships: Challenges for Future Maritime Education and Training. *INTED2018 Conference, Valencia, Spain.* ISBN: 978-84-697-9480-7. DOI: 10.21125/inted.2018.2374.

Bertram, V. and Plowman, T. 2019. Digital training solutions in the maritime context: Options and costs. *Maritime Technology and Research.* 2(2).

Gekara, V.O.; Bloor, M; Sampson, H. 2011. Computer-based assessment in safety-critical industries: the case of shipping. Journal of Vocational Education and Training. 63:1, 87-100, DOI: 10.1080/13636820.2010.536850

IMO. 2002. Issues to be considered when integrating computer-based technologies into the training and assessment of seafarers.

Lukas, U.F. 2010. Virtual and augmented reality for the maritime sector – applications and requirements. 8th IFAC Conference on Control Applications in Marine Systems. 196-200. DOI: 10.3182/20100915-3-DE-3008.00045

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CLIMATE ACTION AND MARITIME BUSINESS EDUCATION: THE PEDAGOGY OF EXPERIENTIAL LEARNING

Madhubani Ghosh
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Abstract

International Maritime Organization (IMO) is implementing stringent fuel standards to regulate sulphur content and setting targets to meet climate compatible goals. Mitigation actions compatible with global climate stabilisation have both challenges and opportunities for maritime business. These regulations are expected to impose high cost burden on various economic actors in the sector causing significant disruption. At Massachusetts Maritime Academy (MMA), an experiential learning (EL) initiative in the International Maritime Business (IMB) program, introduces and exposes students to major maritime hubs where they engage with industry practitioners to understand the latest environmental policies and their likely impacts. It also provides a collective learning ambience through improvement of cross-cultural awareness. This paper summarises the development of cultural quotients of participating students and their understanding of environmental regulations and sustainability practices as explained by various maritime stakeholders during a recent EL trip to Singapore. It uses experiential learning program and the survey results as a case study to assess bottom-up capacity building in maritime education.

Key words: Climate change, sustainable development goals, experiential learning, maritime education, emission standards

1. INTRODUCTION:

The international shipping industry is responsible for the carriage of around 90% of world trade[1]. Without ocean shipping, intercontinental trade, the bulk transport of raw materials, and the import/export of affordable agricultural and manufactured goods would be impossible. This benefits consumers by creating choice and affordability, boosting economies and creating employment. Ocean shipping is the most economical and environment-friendly compared to all other modes of transportation of bulk cargo[2]. Global seaborne trade is responsible for transporting vital raw materials, agricultural and manufactured commodities across the world and reached the massive volume of 10.7 billion tons in 2017[3]. With globalisation, the volume of goods traded by sea has grown by 300 percent since the 1970s, according to the United Nations Conference on Trade and Development (UNCTAD). UNCTAD also predicted in 2017 that seaborne trade volumes would increase by around 3.2 percent each year until 2022. This benefits consumers by creating choice and affordability, boosting economies and creating employment.

However, while the shipping industry is vital to modern life, it is also responsible for emitting around a billion tonnes of carbon dioxide (CO_2) a year[4]. Sulphur Oxide emission is another huge problem[5]. The most economical type of fuel oil for ships is bunker oil that is a residue derived from crude oil distillation and has high sulphur content. In 2016, global demand for high-sulphur fuels stood at around 70 percent of overall bunker fuels[6].

IMO 2020 regulation is to cut down sulphur emission by half in mid-century compared to 2008. These are aimed at preventing impacts like acid rain with harmful impact on agricultural crops forestry and ocean acidification.[6] A study[7] on the human health impacts of SOx emissions from ships, submitted to IMO (International Maritime Organisation)'s Marine Environment Protection Committee (MEPC) in 2016 by Finland, estimated that by not reducing the SOx limit for ships from 2020, the air pollution from ships would contribute to more than 570,000 additional premature deaths worldwide between 2020-2025. This study and its findings jolted the international community in taking a bold step in curbing maritime SOx pollution. In order to complement the United Nations Framework Convention on Climate Change and the 2030 agenda for sustainable development Goal 13, IMO has embarked upon an ambitious agenda of reducing greenhouse gas emission from ships by 50% within 2050 compared to the baseline of 2008. Mandatory data collection systems for fuel oil consumption in all ships above 5000 gross tons are in effect from January 2019. Mitigation actions compatible with global climate stabilisation goals and sustainable development goals have both synergies and trade-offs. For long term sustainable development, there is need for enhancing synergies and minimising trade-offs. Transportation is a critical sector in this context. However, knowledge gap so far in maritime transport sector has been conspicuous by their absence in 2018 Special Report of IPCC on 1.5 °C Global Warming.[8]

There has been ongoing interdisciplinary research on the overall challenges of ocean sustainability that include living and non-living resource extraction (such as aquaculture, fisheries, underwater mining) as well as non-extractive industries such as shipping and tourism.[9, 10, 11, 12] However, challenges and opportunities emerging from the need for global climate action and nature of response from international maritime transport sector is limited in the literature. How this sector is coping and what are the barriers for change; what kind of preparedness exists and what bottom up efforts are emerging towards capacity building for transformative change are some of the least addressed questions in mainstream climate change literature. This paper attempts to fill this gap through a modest effort. Also, there is less understanding of the various cost and technological barriers which maritime shipping sector is facing as IMO is trying to implement various regulations compatible with global climate change mitigation actions. This paper attempts a comprehensive mapping of recent environmental friendly policies, identifies the target sectors in the maritime space and summarises attempts of integrating these in maritime education for future managers of maritime business.

Massachusetts Maritime Academy (MMA) pursues an international experiential learning (EL) program that takes students to major maritime hubs where students engage with industry practitioners to understand the impact of the latest environmental policies and also improve collective learning through cross-cultural awareness. The paper uses this experiential learning program of January 2019 to Singapore, a pre and post trip Cultural Quotient (CQ) [13] assessment and a questionnaire based survey among the participating students to assess students' understanding of sustainability practices in the maritime sector as well as their CQ.

2. OCEAN SHIPPING: FUEL QUALITY REGULATIONS:

IMO regulations to reduce sulphur oxide (SOx) emissions from ships first came into force in 2005, under Annex VI of the International Convention for the Prevention of Pollution from Ships (known as the MARPOL Convention). Since then, the limits on sulphur oxides have been progressively tightened. From January 1, 2020, the limit for sulphur in fuel oil used on board ships operating outside designated emission control areas will be reduced to 0.5% m/m (mass by mass). This will significantly reduce the amount of sulphur oxides emissions from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coastal regions.

a) SOx 2020: Stringent policy:

The IMO's Marine Environment Protection Committee (MEPC) guidelines of 2019 provide advice to the maritime community for consistent implementation of the 0.5% sulphur limit[14]. Among other guidelines, it points out key technical considerations for ship-owners and operators such as ship tank configuration and fuel system, tank cleaning recommendations, fuel heating requirements, *etc.* It also provides several monitoring guidelines for Flag and Port State Control agencies which can help in enhancing fuel efficiency.

However, although many ships are incrementally becoming more and more energy efficient over time,[6] given the limits specified for maximum permitted sulphur content, there are several vessels that burn fossil fuel such as bunker fuel responsible for air pollution. In order to address this issue, the IMO MARPOL regulations have mandated a stringent regulation for sulphur content of bunker fuel, substantial cut in SOx content from 3.5% m/m (mass by mass) to 0.5% m/m by January 1, 2020. From that date onwards, ship-owners and charterers around the world can only legally take on bunker fuel with a maximum sulphur content of 0.5%, down from the current level of 3.5%. If they are found in breach of the IMO's new regulation, they will face penalties and their vessels will be declared unseaworthy and, therefore, uninsurable. There is an even stricter limit of 0.1% already in effect in emission control areas (ECAs) such as the Baltic Sea are, the North Sea area, the North American area and the United States Caribbean Sea area.

Fuel oil companies already provide such ultra-low sulphur fuel oil blends to ships that trade in the ECAs. They would have to gear up to the new regulations and provide large quantities of low sulphur content blends that would meet the 0.5% emission stipulation for all vessels plying worldwide.

b) Stringent policy: cost implications:

Ships are gearing up to respond to stringent fuel standards in a variety of ways. Some are trying to limit pollutants by installing end of pipe solutions such as through installation of exhaust gas cleaning systems called scrubbers that allows them to continue to use high sulphur content fuel oil. Out of about 90,000 commercial ships plying worldwide, only 494 ships installed scrubbers by May, 2018. This might seem like a drop in the ocean however, can be explained by the high cost for scrubber installation of about $10 mn per ship[15].

In the longer term, substitute fuel like liquefied natural gas (LNG) is expected to become a more prominent part of the shipping sector's fuel supply. LNG produces almost no SOx or particle matter emissions and generates about 90 percent less NOx, according to the OECD[16]. Burning LNG also produces 20 to 25 percent less CO2, which the IMO is also aiming to limit. Challenges remain around the infrastructure needed to support the use of LNG. However, it is expected that this might initially be limited to new ships.

A major concern among the shipping companies is a supply constraint and possible non availability of regulation compliant fuel oil. MARPOL Annex VI states that in the event that compliant fuel oil cannot be obtained, a monitoring agency can request evidence outlining the attempts made by the shipping company to procure the fuel oil and a Fuel Oil Non Availability Report (FONAR) be submitted. The monitoring agency should investigate all such claims to ensure authenticity and address supply constraint issues. The submission of FONAR is not an automatic exemption and is to be followed by a thorough investigation. A study commissioned by IMO into the "Assessment of fuel oil availability" in 2016 [17] concluded that the refinery sector has the capability to supply sufficient quantities of bunker fuels with a sulphur content of 0.50% m/m or less and with a sulphur content of 0.10% m/m or less to meet demand for these products, while also meeting demand for non-marine fuels.

The MEPC guidelines of 2019[14] also provide detailed guidance on implementation planning. They cover:

- Risk assessment and mitigation plan (impact of new fuels);
- Fuel oil system modifications and tank cleaning (if needed);
- Fuel oil capacity and segregation capability;
- Procurement of compliant fuel;
- Fuel oil changeover plan (conventional residual fuel oils to 0.50% sulphur compliant fuel oil);
- Documentation and reporting.

Also vessels currently operating with 3.5% sulphur content fuel will need to do a thorough clean- up of its tanks, pipes and other equipment before the transition to the 2020 compliant fuel. This could take as long as six months and comes with a significant price tag to the ship-owner who also needs to count the opportunity cost of an idle vessel. The enforcement of the regulation might vary significantly depending on the location of the vessel. A noncompliant vessel may even be deemed unseaworthy and may not be insurable.

It is evident from the above that this new regulation is going to have a tremendous economic impact on the maritime community which seems to be stuck between a rock and a hard place. Mitigation actions compatible with global climate stabilisation goals and sustainable development goals have both synergies and trade-offs. For long term sustainable development, there is need for enhancing synergies and minimising trade-offs. It is therefore prudent to explore the concerns of the maritime community in meeting these guidelines.

The higher cost and possibly restricted availability of low sulphur fuel is a major concern[4]. Consulting firm Wood Mackenzie estimated moving to lower-sulphur fuels could send shippers' costs up by as much as $60bn in 2020. Shipping companies like Hapag-Lloyd, announced a "Marine Fuel Recovery" surcharge mechanism, claiming that the transition will cost the company $1bn in the first year. Other carriers have cited figures closer to $2bn in costs. A ripple effect is expected on refiners who will need to raise prices in order to increase the supply of compliant fuel. Conservative estimates forecast a 50% increase in fuel price. All this would significantly increase the cost of ocean transport and much of this cost burden will fall on the final consumer. A 2018 Drewry study[18] shows that the maritime community is quite unprepared to realise the cost impact as only 10% of the shippers worldwide have done an actual cost impact assessment. Currently most stakeholders seem to be on a wait and watch mode nervously anticipating the regulatory fallout as 2020 rolls around.

c) Climate Action and Targets: GHG and CO2 2030:

In 2018 MEPC adopted the initial strategy of reducing Green House Gas (GHG) emissions from ships by 50% in 2050 compared to 2008[19]. This was submitted by IMO to the UNFCCC Talanoa Dialogue in support of taking urgent action to combat climate change and its impacts. IMO also plans on reducing CO2 emissions by at least 40% by 2030 and 70% by 2050, compared to 2008. Short, mid and long term strategies have been identified to attain these targets.

Short term measures include establishing an existing fleet improvement program, speed reduction of vessels and establishing speed limits, port infrastructure development to provide shore power to ships in port, logistical optimization coordinating just in time arrival of ships in ports, design refinements such as hull and propeller optimization, incentives to first movers in technological innovation etc. Some important mid-term measures are market based measures to incentivize GHG emission reduction, information exchange on best practice, *etc*. Long term measures include development of zero carbon fossil free fuel use in shipping such as hydrogen. Special attention to be given to the needs of developing countries, small island developing states and least developed countries to ensure that their needs are properly assessed and addressed.

In its 2019 report on Low Carbon Shipping Outlook, ABS[20] mentions that such a significant lowering of the carbon footprint of an industry that moves almost 90 percent of global trade is a significant undertaking. Such large scale change will not come quickly and great efforts will be required to ensure that shipping's positive contributions to global trade and the economy continue to remain viable. The path to a low-carbon future will involve new technologies and operating procedures and safety will be an even stronger focus for the shipping industry.

Because the challenge is complex, there is a need for integrated, interdisciplinary and cross sectoral approaches, bringing together natural and social sciences, as well as policymakers, academicians, resource managers, industries, citizens and other societal partners.

d) IV Maritime Education: Bottom up capacity building initiative:

Given the need for transformative changes in various system levels in response to climate change, literature is engaged in discussion on the role of pedagogy, educators, and learners in driving transformative changes[21]. Based on the generally accepted premise that learning occurs through application, experiential learning MMA started a new pedagogy and role of learners and educators. The International Maritime Business (IMB) major has integrated this carefully into the curriculum, ensuring proper integration between the experience and the educational value that can be derived from it. All sophomore students are engaged in a five-week faculty led program which is divided into three segments. This includes a pre-departure awareness and understanding, a three-week travel program in an international location, and a weeklong post-travel reflection activity involving a presentation and final report submission. In the learn-do-learn tradition of MMA, the centrepiece of this course is the three-week field study in a selected country absorbing the practical, regulatory and cultural implications of international maritime business. This is allowing scope for practical, collective and critical learning.

Fourteen IMB students travelled on their experiential learning tour to Singapore during January-February, 2019 to engage with various organizations in the maritime sector to learn about current issues and regulatory impact on global maritime business. The cadets followed a well-defined schedule on location. They visited various maritime business interests, participated in industry talks and seminars and interacted with several maritime professionals. During their stay in Singapore, they also experienced a complete cultural immersion. Some of these students had never stepped out of the US prior to this trip. An important element of this exercise was an assessment of cultural intelligence quotient (CQ). CQ is an individual's capability to function effectively in situations characterized by cultural diversity[13]. To assess their learning attainments and change in world view, educators used a pre and post trip CQ assessment. A questionnaire method was also used to elicit changes in learners through this method of experiential learning.

The importance of a proper CQ assessment for the purpose of understanding and enhancing a maritime student's world view can hardly be overemphasized. In a world, where crossing geographical boundaries is routine, and in a profession like maritime business where the sun never sets, CQ is a vital skill. Each student was subject to a pre departure CQ assessment and a post trip CQ assessment conducted by Cultural Intelligence Center, an external assessment consultant. A comparison of results between pre departure CQ (T1) and post trip CQ (T2) demonstrated a marked improvement in CQ for the students, as shown in Table 1. The four CQ factors are defined below[22].

1. CQ Drive is a person's motivation, interest, and confidence in functioning effectively in culturally diverse settings.

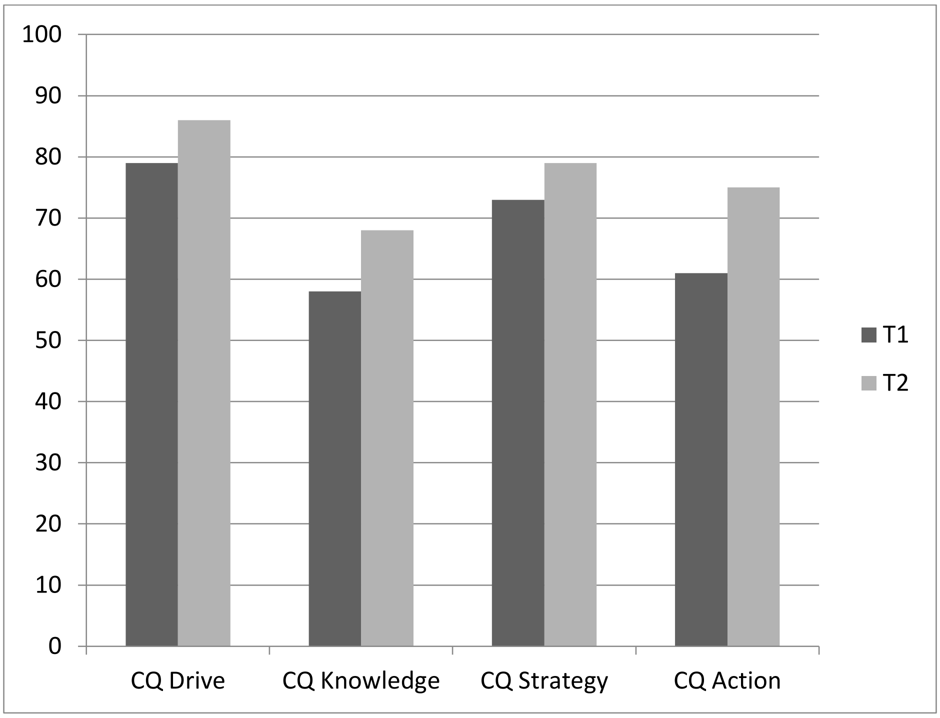
2. CQ Knowledge is a person's knowledge about similarity and differences of cultures

3. CQ Strategy is how a person makes sense of culturally diverse experiences.

4. CQ Action is a person's capability to adapt verbal and nonverbal behavior so it is appropriate across cultural contexts.

Table 1

Comparison of T1 and T2 Assessments



It was heartening to see average scores between T1 and T2 increase 9% for CQ Drive, 17% for CQ Knowledge, 8% for CQ Strategy and 23% for CQ Action due to the experiential learning trip to Singapore.

An issue that repeatedly came up in the various meetings and presentations with maritime businesses in Singapore was the impact of regulatory changes emerging in response to climate change. Across the entire maritime spectrum, there were discussions on how the SOx 2020 and subsequent GHG and CO2 2030 regulations will impact the industry. Shipping companies like APL informed the students about how they were gearing up to meet the challenges imposed by the new regulations. The port of Singapore representatives spoke about how the port was preparing for a green initiative in keeping with the new regulations. Various maritime insurance companies like North of England P&I spoke about insurance liabilities should a vessel be deemed unseaworthy in failing to meet with the regulations. The same message reverberated in other maritime companies such as charterers, brokers, ship management companies and shipyards. The message about how maritime companies are reacting to the new emission regulation was conveyed to the students loud and clear. Table 2 provides a summary of the salient points made by the various stakeholders.

Table 2

Summary of Stakeholder Consultation

The Maritime Stakeholders	Comments
Charterer and broker	Burning bunker fuel contributes to 90% of all sulphur emissions globally. IMO 2020 will be one of the most dramatic regulatory changes in the history of the maritime sector. This will increase fuel costs which through higher freight rates will be passed on to the consumer. If there is full compliance, then the cost to the consumer could be $240 bn in 2020 according to Goldman Sachs. Low sulphur content fuel will be in high demand thus pushing up prices. To offset fuel costs ships might travel at slower speed. While allowing better compliance and lower fuel costs this will mean delayed delivery of products. Low sulphur fuel shortage could crop up in certain regions causing detours for vessels. While emissions are regulated, the actual sulphur content of the fuel is not. Ships can therefore install scrubbers to reduce emission. This will transfer the sulphur to a disposal unit which could be emptied in the ocean. Forecasts of scrubber installation in 2020 could be only 5% of the current shipping fleet. Oil refineries will see higher profits as a result of the regulation. The short term impact will definitely be higher freight rates which will hurt the consumers.
Shipping Company	We have continued to advance in reducing carbon footprint, cutting sulphur emissions and protecting ocean biodiversity. We will ensure compliance when the IMO 2020 Sulphur Cap regulation becomes effective from 1 January 2020. We will combine the use of low-sulphur compliant fuel oil; exhaust gas cleaning systems or "scrubbers" and LNG-fuelled vessels. We will stay fuel efficient and be transparent in fuel pricing to help shippers operate under the new business environment. However, as a result of rising oil prices which might take place in 2020, an Emergency Bunker Surcharge (EBS) may have to be re-evaluated. The sustainability goals are set to be achieved through fleet renewal, technology innovation, optimal operations, clean energy sources, best practices and benchmarking.
Marine Insurance Company	Once a shipping company switches to compliant fuel, it will then need to check if the charter parties or contracts reflect the preparation plan to ensure that everything goes smoothly, without any delays or disputes. If possible, it would be better to discuss this switch with charterers and agree on the plan of action. Even if vessels have been fitted with scrubbers, one might still need to take steps to prepare the vessels for 2020, and the charter parties.

The Maritime Stakeholders	Comments
	Unfortunately, there is no *magic* charter party clause to deal with all of the issues that might arise. A number of clauses to deal with 2020 issues have been drafted including transition clauses in existing charter parties that will span 1 January 2020.
Classification Society	The regulatory changes set for 2020 as well as those expected for 2030 and 2050 will be more disruptive than any past environmental regulations. Lowering the carbon footprint of an industry that moves almost 90% of global trade is a significant undertaking. 2030 targets can be met with available technology - slower speeds, improvements in operational efficiency, limited use of low-carbon fuels, and energy efficient designs. Fuels are in focus to achieve 2050 emissions targets. It has taken ten years for LNG bunkering infrastructure to develop and supply less than 1% of the global fleet. Other alternative fuels will face similar infrastructure development, regulatory and supply chain challenges. There are currently no truly "zero-carbon" fuels at a larger scale and "carbon-neutral" bio-fuels are tested in limited quantities. All alternative fuels known at this time have certain limitations. There is no obvious fuel choice for the global fleet. For the immediate future the fuel solution for a vast part of international shipping remains a choice between a variety of fuel oils or LNG.
Port Administration	With regards to the IMO Low Sulphur Fuel regulation, the shipping community is more concerned about the fuel availability and cost of implementation to meet this coming international requirement. Our preparation in the port of Singapore is largely to ensure fuel availability and strict compliance to this new regulation, so as to create a level playing field for all operators (due to a huge price difference between the two types of fuel). With regards to GHG, port emission is under the purview of the state and this is reported to UNFCCC, under states' measures to combat climate change. Most states have pledged to reduce their GHG emissions, like Singapore. In our case, we have pledged to reduce our emissions intensity by 36% by 2030, as compared to our emissions in 2005. In our port, we are focusing on efficiency of ship energy usage through proper management, new and lower carbon footprint fuel such as LNG and bio-fuels, electrification of port systems like cranes, AGVs, *etc.* to replace diesel equipment, and will be looking at electric vessels going forward.

Source: Feedback received during field trip

An online survey was also conducted on the 14 students upon their return, for their feedback on the EL trip. Of the 64% responses received, the responders indicated the following:

1. On a scale of 1 through 5, (1 being poor and 5 being excellent) all respondents gave a score of 5 to rate the Singapore EL program over all.

2. When asked the question if students were aware of the IMO MARPOL regulation of the cut in SOx emissions from 3.5% to 0.5% m/m by January 1, 2020, prior to the EL trip, 44% of the students indicated that they were unaware.

3. When asked the question if students were aware of the IMO regulation of the cut in GHG emissions from by 50% in 2050 compared to 2008, 44% of the students indicated that they were unaware prior to the EL trip.

4. When asked the question if students were aware of the IMO plan of reducing CO2 emissions by at least 40% by 2030 and 70% by 2050, compared to 2008, 44% of the students indicated that they were unaware prior to the EL trip.

The survey results indicate that there is still a learning gap in student awareness of current and future environmental regulations that will have a tremendous impact on the shipping industry. Such EL trips and interaction with practitioners can be an instrument to bridge this gap.

3. CONCLUSION:

Maritime shipping sector is at a cross road. There is need for responding to stringent policy and regulations to sustain in business but there are high cost implications as well. Environmental sustainability through compliance and business sustenance through cost and benefits assessment of adoption of new abatement technology, new fuel variety or by shifting to new carbon free fuels are providing opportunities as well. Early adopters are emerging as business leaders and the others in the sector is lagging behind in compliance. There can be various lessons which the maritime sector can learn from other sectors like manufacturing industries which started adopting environment friendly policies and actions almost four five decades back. The new changing global climate and response actions are not only to be understood by the shipping companies but also by the several support sectors identified in Table 2 to create enabling conditions. Training and capacity building to drive transformative changes is an important component and education plays a very important role. MMA has initiated and is evaluating the new pedagogy, role of learners and educators in the process of change to set an example for capacity building needs in this sector. CQ evaluation based on experiential learners' feedback shows positive impacts in creating future prospective employees in the maritime sector, who are ready for change. In this paper, we were able to demonstrate that, with the help of strategic partners in the maritime education space, it is possible to create opportunities that will significantly strengthen the CQ as well as regulatory awareness of maritime students. The maritime sector is probably the most global sector with a very diverse workforce. This is also a sector that is subject to very stringent regulations on safety and pollution. It is increasingly important for the maritime professional of tomorrow to demonstrate awareness and proficiencies on these issues. Based on the generally accepted premise that learning occurs through experience, such EL programs can be a critical component of the curriculum in maritime institutions worldwide.

REFERENCES:

ABS 2019: *Sustainability for the maritime sector: Low carbon shipping outlook* https://ww2.eagle.org/en/innovation-and-technology/sustainability-for-the-maritime-sector.html

Ang, S. and Van Dyne, L. ed (2008), *Handbook of Cultural Intelligence*. M.E. Sharpe.

C. R. Anderson, R. Binimelis, M. P. Pimbert, M. G. Rivera-Ferre., 2019: Introduction to the symposium on critical adult education in food movements: learning for transformation in and beyond food movements-the why, where, how and the what next? Agriculture and Human Values. https://doi.org/10.1007/s10460-019-09941-2

Cheung, W.W.L., G. Reygondeau, and T.L. Frölicher, 2016: Large benefits to marine fisheries of meeting the 1.5°C global warming target. *Science***, 354(6319)**, 1591-1594, doi:10.1126/science Aag 2331.

Chong, J., 2014: Ecosystem-based approaches to climate change adaptation: progress and challenges. *International Environmental Agreements: Politics, Law and Economics***,** 14(4), 391-405, doi:10.1007/s10784-014-9242-9.

Costas Paris, 2018: Shipowners' multibillion-dollar quandary: Buy cleaner fuel or a fuel cleaner? https://www.wsj.com/articles/ship-owners-multibillion-dollar-quandary-buy-cleaner-fuel-or-a-fuel-cleaner-1521538200, Wall Street Journal.

Drewry 2018: Low sulphur fuel cost uncertainty weighs heavily on shippers and carriers https://www.supplychaindive.com/news/Drewry-IMO-2020-shippers-carriers-uncertainty/539237/

Earley, C., Ang, S., 2003: *Cultural intelligence: Individual interactions across cultures*. Stanford University Press.

Ekwurzel, B. *et al.*, 2017: The rise in global atmospheric CO2, surface temperature, and sea level from emissions traced to major carbon producers. *Climatic Change*, 1-12, doi: 10.1007/s10584-017-1978-0.

Goldsmith. Courtney, 2019: New sulphur fuel laws look set to shake up the shipping industry, Worldfinance.com. https://www.worldfinance.com/featured/a-costly-change-of-course

IMO 2014: Third IMO greenhouse gas study. London, United Kingdom. http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf

IMO 2016 MEPC 70: Air pollution and energy efficiency: Assessment of fuel oil availability: Final report http://www.imo.org/en/OurWork/Documents/MEPC%2070-INF.6%20-%20Assessment%20of%20fuel%20oil%20availability.pdf

IMO 2016: Air pollution and energy efficiency, Marine Environment Protection Committee, 70th session. https://shippingwatch.com/article9069067.ece/binary/Svovl_tidlig_doed.pdf

IMO 2016: The 2020 global sulphur limit. London, United Kingdom. http://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

IMO 2018: Note by the International Maritime Organization to the UNFCCC Talanoa dialogue https://unfccc.int/sites/default/files/resource/250_IMO%20submission_Talanoa%20Dialogue_April%202018.pdf

IMO 2019: IMO Profile, *Overview*. London, United Kingdom. https://business.un.org/en/entities/13

IMO, 2019: 2019 Guidelines for consistent implementation of the 0.5% sulphur limit under MARPOL Annex VI http://www.imo.org/en/OurWork/Environment/PollutionPrevention/Documents/Resolution%20MEPC.320%2874%29.pdf

IPCC. 2018: Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global

response to the threat of climate change, sustainable development, and efforts to eradicate poverty. World Meteorological Organization, Geneva, Switzerland.
https://www.ipcc.ch/sr15/

Lawrence. David, World Bank 2016: Green sea transport: creative approaches for environmentally friendly shipping.
https://blogs.worldbank.org/ppps/green-sea-transport-creative-approaches-environmentally-friendly-shipping

Nicholls, R.J. et al., 2018: Stabilisation of global temperature at 1.5°C and 2.0°C: implications for coastal areas. *Philosophical Transactions A*, **376(2119)**, 20160448, doi:10.1098/rsta.2016.0448.

OECD, 2010: Green ship technology book https://www.oecd.org/sti/ind/48365856.pdf

UNCTAD 2018: Review of maritime transport.
https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf

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