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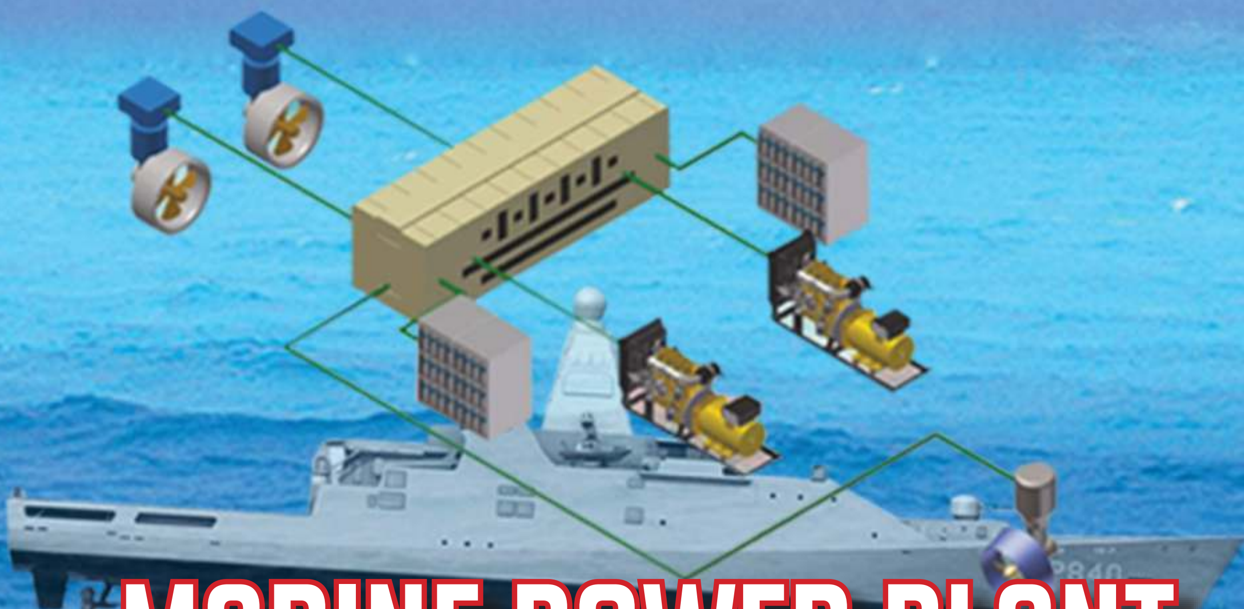
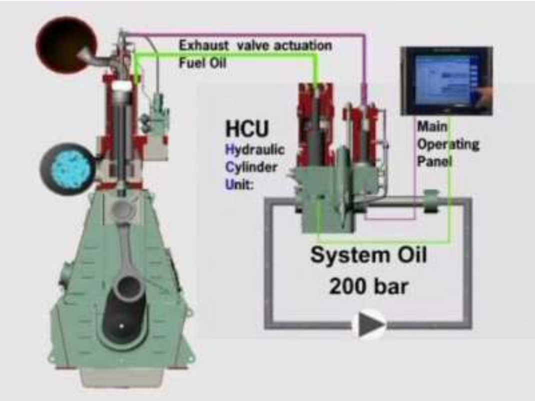


MARINE POWER PLANT MANAGEMENT DEMYSTIFIED

MASSA Maritime Academy, Chennai

The Institute of Marine Engineers (India)

Electronic Engine Familiarisation Course (ME-Type Engine)
Delivered online with Cloud access to ME Engine Simulator



This 3 days course is designed for all Ship's Engineer Officers and Electro Technical Officers responsible for the operation of ME Engine. This course consists of technical lessons and practical instructions on the design, principles, operating procedures and maintenance activities for the safe, efficient and optimal performance of the engine system.

Course Aims and Objectives:

The course aims to provide practical understanding of the principles, design, operation and maintenance of the ME Engine System, enabling participants to safely and efficiently operate the engine and perform fault-finding in the control system.

Coverage / Program Focus:

This course deals with the following training areas:

- **Introduction to ME Engine**
- **Hydraulic Power Supply (HPS)**
- **Hydraulic Cylinder Unit (HCU)**
- **Engine Control System (ECS)**
- **Main Operating Panel (MOP)**
- **Standard Operation**

Entry Requirement / Target Group:

Entry is open to all Ship's Engineers and Electro Technical Officers with basic knowledge of diesel engines.

DATE & TIMING : 16th to 18th **Nov.'21**, 14th to 16th **Dec.'21**, 18th to 20th **Jan.'22**, 15th to 17th **Feb.'22**, 15th to 17th **Mar.'22**.
8:00 am - 4:00 pm IST

VENUE : Web Platform / Zoom**. APPLICATION LINK:** https://forms.gle/e4As7kCucR5xoJBm9

REGISTRATION & PAYMENT : Rs. 15,000/- /- per participant – inclusive of taxes.
For IME(I) Members 13,500/- per participant - inclusive of taxes.
Payment to be made to: https://imare.in/buy-online.aspx
(Under Category - Value added Courses) *10% discount available for IME(I) members*

FOR MORE INFORMATION : **@IME(I) - email:** training@imare.in, Ms. Anukampa
(M). 9819325273, **(T)** 022 27701664 / 27711663 / 2771 1664.
@ MASSA Maritime Academy Chennai - email: mmachennai@massa.in.net
Ms. Saraswathi, **(T)** 8807025336 / 7200055336 .

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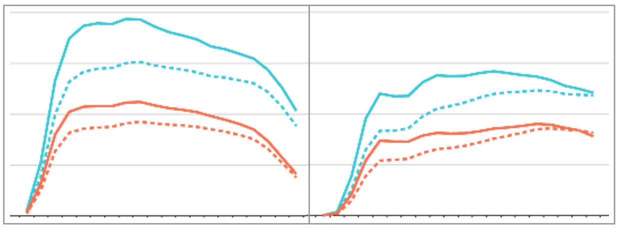
EDITORIAL

The anxiety is unbearable. I only hope it lasts forever.
– Oscar Wilde



Source: 'Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the covid-19 pandemic', by D.F. Santomauro et al., The Lancet, 2021; The Economist, Oct 11th 2021.

The curves could very well be a schoolchild's doodle of a T-Rex and its offspring in the Jurassic Park paddock (behind electrified fence lines). The trend lines tell us something else: Left shows mental disorders due to anxiety and the right due to depression. Blue represent women and red, the men; dots show the pre-pandemic trends, while solid lines show during-pandemic trends. X axis marks the age group from 0-100 years; Y axis shows people affected per thousand (in 100,000).

Anxiety and Depression disorders have increased during the pandemic. More affected are the women. While Africa and Middle East scored high on depression, South Asia takes the trend steeply up on anxiety related disorders. And India is in South Asia. Pressure of household 'unpaid' care, not-so-tight border (read entry-exit points) controls etc., are being attributed to these disorders which include deaths also.

Life could be a long anxiety road and might extend till existence ends all right, but the return to normalcy is one anxiety we wish to bear not any longer.

By the way, we can add IPL also as a reason for our anxieties... I mean the Indian Pandemic Laxness.

In this issue...

Engineering specialisations have galloped into reliability, predictive, preventive and so on, and they have touched all aspects of traditional technology arrangements of many core machinery systems. Marine power plants have evolved not only with optimisation in view but also with environmental needs in focus. Understanding the management of modern marine power plants has become a part of the present day marine engineer's upskilling menu.

We start a six-part series on Power Management with Dr. Vedachalam expounding on the basis of RAMS (Reliability, Availability, Maintainability, Safety) centred power management system. In the introductory part, tracing the drivers for such management systems, Dr. Veda also prevails on few aspects of reliability engineering, which will connect well with the practicing marine engineers. We hope this six-pack power management series will sustain interest amongst the readers.

FPSOs have become a regular store-and-send point for oils emerging from the wells. The structural architecture is comparable to an ocean going vessel, yet hull girder loads could be typical. Greeshma and Dr. Sheeja share a CFD study of an FPSO. Performing the modelling and meshing by software, the regular ship's motions of heave, roll and pitch are analysed using a CFD solver. Further analyses of hull structure responses are also explained. Indicators using such approaches will get us closer to designing hulls which will have better resistance to fatigue loading.

Following this, we have a stability analysis study presented by Dauson Nyonyi and his mentors. In this Naval Architecture calculations, a multi-purpose cargo vessel has been considered and Maxsurf software has been employed. The study considers the IMO Stability criteria while explaining the results and underlining the parameters. This would be a digestible read for marine engineers even with passing interest in Naval Architecture.

In the Competency Corner, LSG continues with his titbits-for-ship operations from various sources.

Under Lube Matters, Sanjiv explains FTIR analysis in a simple fashion.

In the Heritage Hourglass, Amruta Talawadekar recaptures the times when mudflats and marine land were reclaimed to form Bombay and then transform into the modern maritime metropolis of Mumbai.

And we hope that you have accessed the flipbook, pdf versions of MER. Do revert with ideas for improvements on navigation, content, looks...

But for now, here is the November issue.

Dr Rajoo Balaji
Honorary Editor
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In This Issue

ARTICLES

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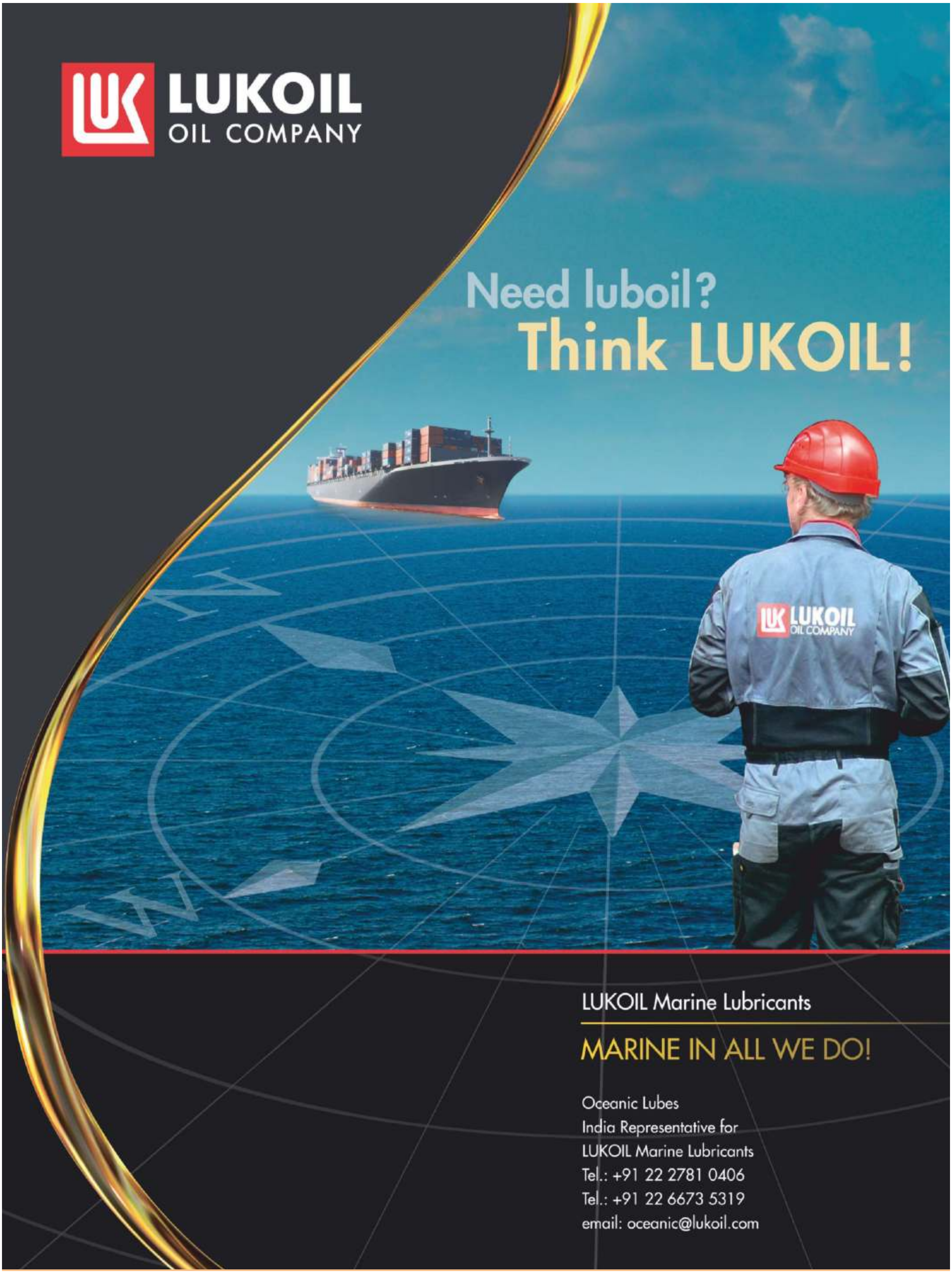
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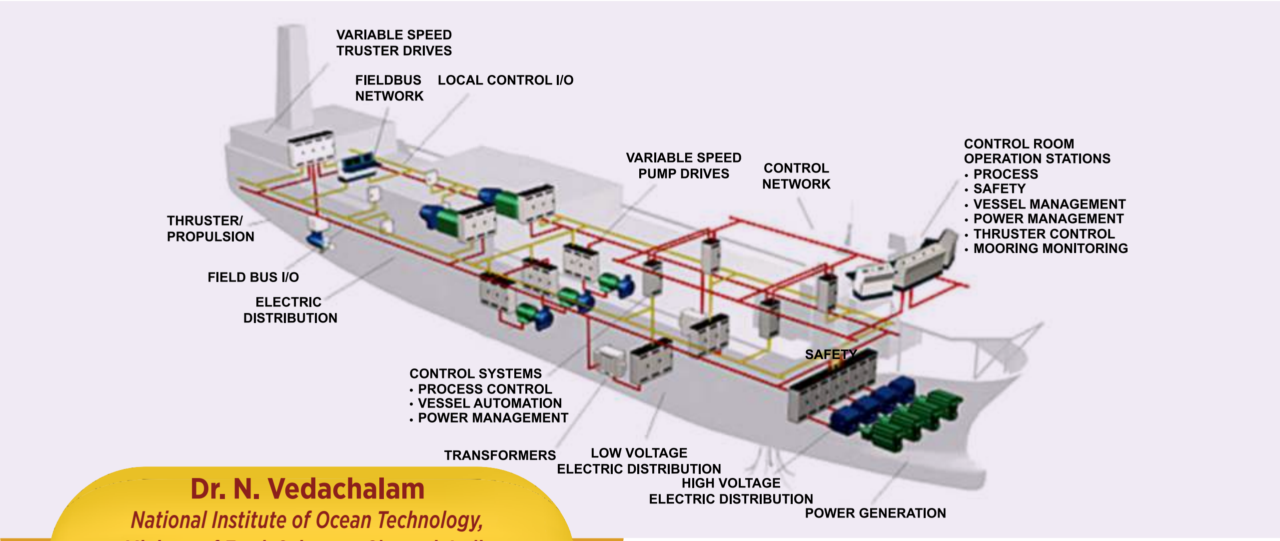
RAMS-CENTRED SYSTEM ENGINEERING AND OPERATIONS OF MODERN MULTI-MEGAWATT MARINE POWER SYSTEMS



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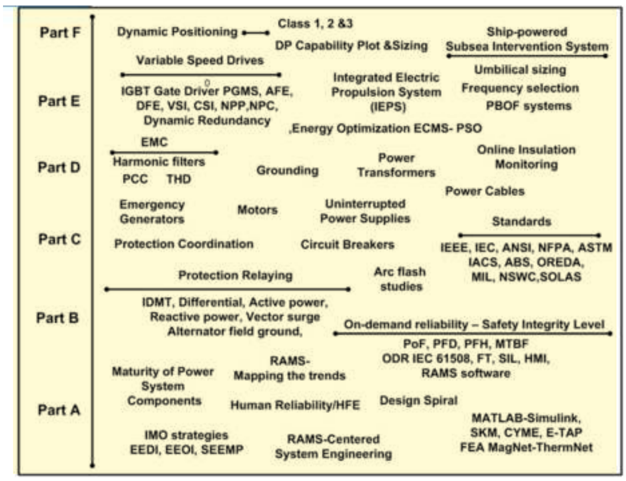
Abstract: Reliability, Availability, Maintainability, Safety (RAMS), operational efficiency and environmental performance are the key requirements for modern multi-megawatt marine power and electric propulsion systems. With the vessel power generating capacities exceeding 100MW, the need for reliable system engineering ensuring system protection and human safety is essential.

This article will be published in six parts discusses the importance, trends and integrated approach to RAMS-centred system engineering, key design and operational considerations for low- and medium-voltage marine power systems, including alternator protection, effective protection coordination, integrity requirements of relaying, emergency diesel generators and uninterrupted power supplies, significance of grounding, condition monitoring of power transformer, cables, motors, harmonics filters and the methodologies for realising fault-tolerant voltage source inverter based variable speed drives and dynamic positioning systems. On-demand reliability analysis based on field-failure data are carried out to identify the health monitoring interval requirements for the life-critical systems. The details presented could be used for safety and reliability-centred system engineering and maintenance planning of multi-megawatt marine power systems.



Index terms: Alternator, Cables, Grounding, Harmonics, Medium Voltage, Motors, Protection Coordination, RAMS, VSD, DP

Introduction

The global fleet of more than 94,171 ships categorised into passenger vessels, containers, tanks, gas carriers, bulk, dry and cargo carriers, with a consolidated dead weight tonnage (DWT) of ~2 Billion Tons contribute to ~90% of the global trade [1]. The International Maritime Organization (IMO) has adopted strategies to increase the operational efficiency and reduce greenhouse gas (GHG) emissions from the ships by ~50% by 2050 through effective implementation of strategies including Energy Efficiency Design Index (EEDI), Energy Efficiency Operational Indicator (EEOI) and Ship Energy Efficiency Management Plan (SEEMP) [2].

Considering the operational, economic and environmental benefits such as reduced fuel costs, redundancy, excellent torque-speed characteristics (including fast dynamics), reduced vibrations, and use of common power source for propulsive and non-propulsive loads, have led to the increased adoption of Integrated Electric Propulsion System (IEPS). As power system is the lynchpin for vessel operations, its reliability and safety are of paramount importance. Hence designing a vessel electrical power generation and distribution network requires a careful trade-off between various design factors, in which ensuring system and human protection are the key factors.

This article will be published in six parts. This first part discusses the maturity of the power systems, importance of RAMS-centred system engineering aspects, evolution of modern RAMS engineering methodologies and tools for determining the reliability and on-demand reliability for time-critical systems and the integrated approach followed in the other parts of the paper for determining the RAMS metrics for the modern multi-megawatt marine power systems.

Maturity of Vessel Power Systems

The power generation capacity has reached ~120 MW for cruise liners of ~230000 GT, 360m long, 47m beam and speed >20 knots; and ~80MW for multi-mission stealth ships. They include Integrated Full Electric Propulsion (IFEP) systems that use diesel generators for base load and gas turbines to meet the peak loads, to generate electricity for electric motors, where there is no mechanical transmission to the propellers.

The vessel diesel-electric propulsion is a key safety and mission critical component of the overall system as non-operation or malfunction could be catastrophic. A typical MV multi-megawatt marine power system (**Figure 1**) comprises of diesel engine/steam turbine-driven alternators connected to the main distribution MV bus operating at voltages 6-15kV. From this arrangement, propulsion and utility loads are supplied through variable speed drives (VSD) operated using power electronics.

Several utility transformer feeders are used to supply the remainder of the vessel's electrical load, the consumer voltage typically being 415V. The system protection is ensured by proper coordination of protection relays and proper rated circuit breakers capable of isolation during a fault.

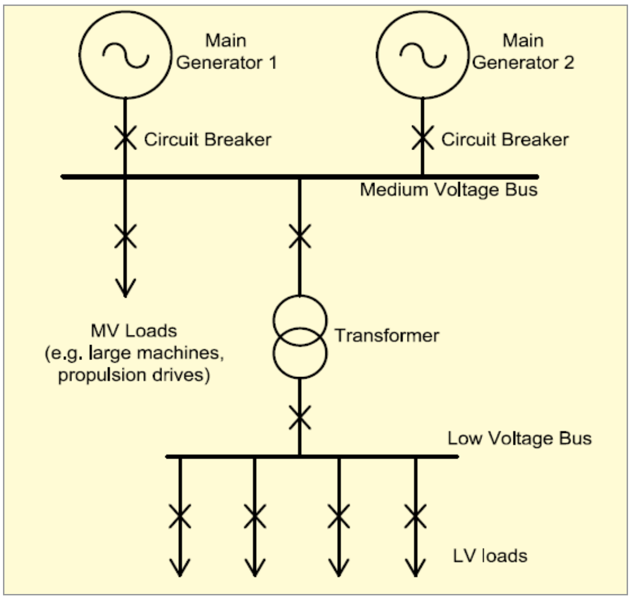


Figure 1 Typical marine medium voltage power system

Their large capacity, low impedance power distribution networks have resulted in extremely high fault current levels, mainly due to the physical proximity of generation and loads, and the use of high cross-sectional electric conductors. The fault levels in the medium voltage (MV) and distribution networks reach an asymmetric peak current of 100kA and 220kA, respectively. The increasing sensitivity and complexity of many non-linear

A typical MV multi-megawatt marine power system comprises of diesel engine/steam turbine-driven alternators connected to the main distribution MV bus operating at voltages 6-15kV

loads places additional burden on effective harmonics mitigation, electromagnetic compatibility and realising effective protection coordination.

Thus, to ensure safety, high capacity power systems are designed to reduce the fault levels by optimised system engineering considering reliability, safety, efficiency and maintainability trade-off. The techniques for reducing the fault currents include distributing the power system to reduce the amount of generation supplying a fault, increasing transformer reactance, incorporating series-connected reactors and solid-state switchgears with fault limiting capabilities.

In naval ships, the power system architecture is damage-tolerant and the protection coordination is responsive to the changes in the vessel's state of battle-alertness to maximise fight-through capabilities.

Advanced electrical network modelling and simulation tools help to analyse the power system dynamics, transients and determine the adequacy of the protection required for fast fault clearance and high levels of discrimination selectivity. In order to ensure the on-demand availability of the emergency power sources such as emergency generators and uninterrupted power supplies, their proof test interval (PTI) requirements needs to be identified.

During emergency manual operations, the human reliability factors are to be factored in the system design. The off-line and on-line condition monitoring systems and practices for motors, transformers, cables, safe grounding techniques, fault-tolerant variable speed drives and redundant dynamic positioning systems require detailed engineering studies. Based on the reliability statistics reported by IEEE [3], OREDA [4] and published literature, the maturity of the electrical subsystems, in terms of probability of failure (PoF) is mapped in **Figure 2**.

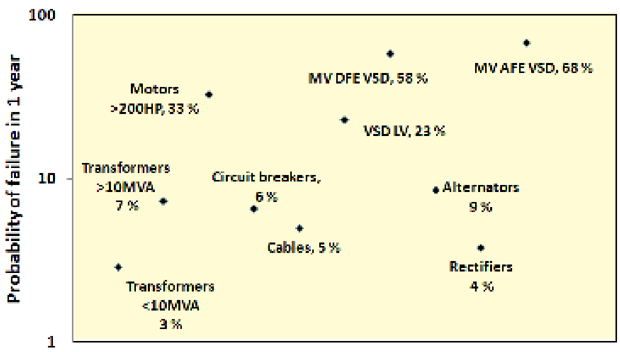


Figure 2 Failure rates of power system components/subsystems

RAMS-centred System Engineering

System engineering based on ISO/IEC 15288 and ISO/IEC 19760 standards provides guidelines for the development of system architecture, defining and allocating requirements, evaluating design trade-offs, balancing technical risks between systems, defining interfaces, providing oversight of verification and validation activities, as well as other associated tasks [5].

Modern RAMS-centred system engineering utilises information about the system to identify sources of risk and risk drivers, and provide important inputs for system design and operations. In the early phases of a project, RAMS analysis helps designers understand the inter-relationships of requirements, constraints, and resources, and uncover key relationships and drivers so that they can be properly considered.

As the design matures, preliminary reliability analysis is carried out using established techniques. The design and the Concept of Operations (ConOps) are thoroughly examined for accident initiators and hazards that could lead to mishaps (**Figure 3**).

A reliable marine power system ensures mission success by functioning safely and reliably over its intended life. It should have a low and acceptable PoF achieved through simplicity, proper design and proper application of reliable parts and materials. In addition to long life, a reliable design should be robust and fault-tolerant, which implies it can tolerate failures and variations in its operating parameters and environments.

The fault levels in the medium voltage (MV) and distribution networks reach an asymmetric peak current of 100kA and 220kA, respectively

Conservative estimates of likelihood and consequence of hazards are used as a basis for applying design resources to reduce the risk of failures. During the project realisation, risk assessments and reliability techniques are used to verify that the design is meeting its risk and reliability goals, and to help develop mitigation strategies when the goals are not met or discrepancies /failures occur.

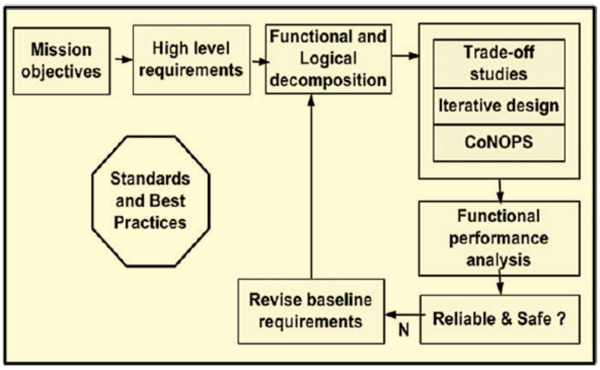


Figure 3. Modern RAMS-centred system engineering

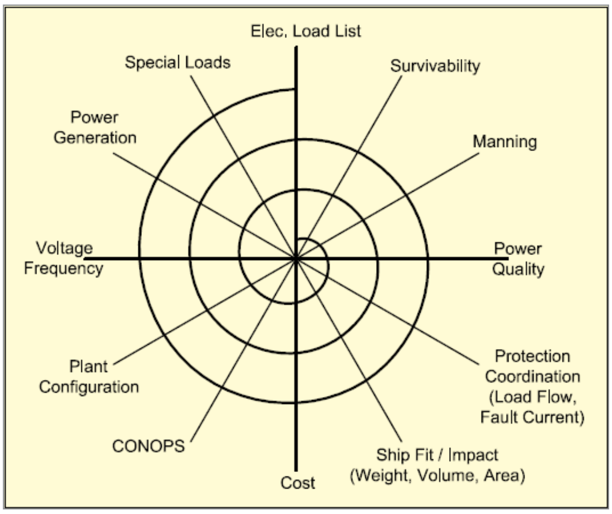


Figure 4. Iterative system engineering of vessel power systems

The fidelity to which safety and reliability are designed and built into the system depends on the vessel's mission requirements. As power systems are critical component of a vessel involving human safety, reliability, availability, maintainability and safety, RAMS-centred system engineering are primary throughout the design phase.

For non-human involved marine systems, RAMS should be commensurate with the funding and level of risk a project is willing to accept. Hence it is essential to integrate RAMS as an intricate component in the iterative system design process (**Figure 4**), operation and life cycle management of the marine power systems.

Modern vessel power system engineering should ensure that systems are designed, built and operated so that it accomplishes its purpose safely in the most cost-effective way possible considering performance, cost, schedule and risk. The design and the operational guidelines by the Institute of Electrical and Electronics Engineers (IEEE), International Electro-Technical Commission (IEC) and International Association of Certification Agencies (IACS) for vessel power and propulsion systems emphasise on vessel and human safety at sea [6][7].

RAMS-Mapping the trends

Based on the experiences from World War 1 and 2, the need to consider reliability engineering as an integral sub-discipline of systems engineering was well understood. In 1920, the product improvement through the use of statistical process control was undertaken by Bell Labs, around the time Waloodi Weibull was working on statistic fatigue models.

The modern use of the word, 'reliability' was defined by the U.S military in the 1940s, characterising a product that would operate when expected and for a specified period of time. Understanding the importance of reliability, the IEEE reliability society was formed in 1948. During 1950, the US Department of Defence formed the advisory group on the reliability of Electronic Equipment to investigate reliability methods for military equipment, that later recommended ways to improve component reliability, establish quality and reliability requirement for manufacturers, collect field data and identify the root cause of the failures.

Over the past six decades, based on the lessons learnt from the catastrophic failures in space, marine, offshore oil and gas, power generation, chemical and transportations sectors (**Table 1**), the importance of RAMS-centred system engineering gained importance.

The evolution of RAMS standards, tools and databases since 1970 is mapped in **Table 2**.

In case of systems involving human intervention during critical operations, Human Factors Engineering (HFE) is considered as a critical part of the design process. HFE studies human-machine interfaces and provides requirements, standards and guidelines to ensure the human component is well integrated. Methods for estimating the HFE parameters described in the UK Atomic Energy Authority (UKAEA) document SRDA-R11 includes anthropometry & biomechanics, sensation and perception, environment, temperature & lighting, and physiological factors (**Figure 5**).

Table 1. Safety-rated catastrophic accidents

Period	Safety-related accidents/breakdowns
Till 1970	Apollo 13, Torrey Canyon oil spill, RMS Titanic sinkage
1970-1980	Tenerife airport disaster, Three miles island nuclear reactor meltdown, Flixborough chemical plant explosion, Seveso chemical industry accident, Exon Valton oil spill, French power grid collapse
1980-1990	Bhopal gas tragedy, Chernobyl nuclear disaster, Piper Alpha oil platform accident, Challenger space shuttle accident
1990-2000	MS Estonia ferry sinkage, Eschede train accident, Ariane rocket launch failure, Concorde flight accident, Paddington rail accident
2000-2010	Prestige oil spill, European power grid collapse
2010-2020	Macondo oil spill, Fukushima nuclear disaster, Coasta Concordia ship grounding, Lac magantic rail disaster, Santiago de Compostela derailment, Boeing 739 Max8 crash, Grande America sink and oil spill , Indian power grid collapse

Table 2. Evolution of RAMS tools, standards and database

Period	Tools, Standards and databases
Till 1970	Markov analysis[1906], FMECA[1940], HAZOP[1960], Probabilistic Safety Studies[1960], MIL-217[1965], THERP[1963], MIL STD-882[1969], PHA[1969]
1970-1990	OREDA[1982] , ISO 6527[1982], SDRF database for nuclear[1984], HRA HEART[1985],BDD[1986], Markov model[1986]
1990-2010	MIL HDBK 217[1995], IEC 60300 Collection of data [2004], Markov standardisation IEC 61165[2006], ISO Guide 73[2009], IEC 61508 functional safety[1998] , IEC 61511[2003] , SysML[2005]
2011-2015	ILS[2011],RBT[2011], Petrinet[2012], IEC62551[2012], ISO/TR 12489[2013],IEC Guide 51[2014], Quantenium 217 plus[2015]
2016-2018	HAZOP standardisation IEC 61882[2016], ISO 14224 Collection of data[2016], IEC 60300 life cycle costs[2017], RCM IEC 60300-3-11[2017], ISO 20815[2018]
2019- Till date	Alta Rica[2019], FMECA standardisation IEC 60812 [2019], IEC 31010[2019], UML[2020],ALARP [2020], PERD CCPS 202[2020], IEC 63142[2020]

HFE analysis are carried out based on data-driven techniques such as Human Error Assessment and Reduction Technique (HEART), Technique for Human Error Rate Prediction (THERP) and Empirical Technique to Estimate Operator Errors (TESEO); Success Likelihood Index Method (SLIM) based on structured expert opinion and Human Cognitive Reliability Method (HCR) based on accident data.

Operational errors could be reduced by training the operating personnel using simulators, improved ergonomics, hardware interlocks and software interlocks. Human reliability analysis studies done by an

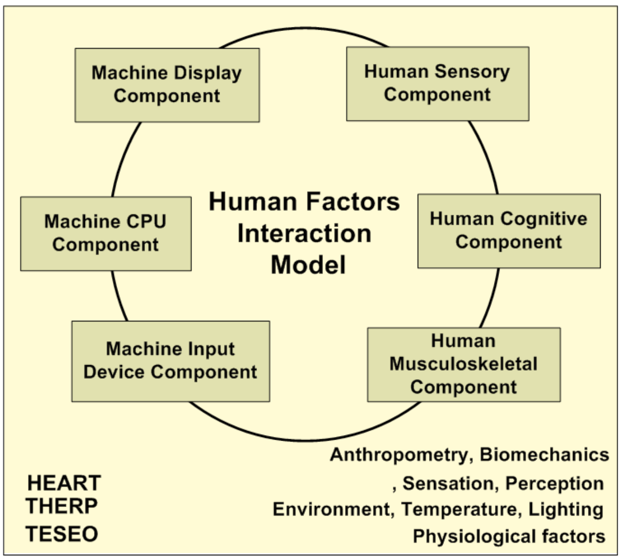


Figure 5. Factors considered for human reliability assessment

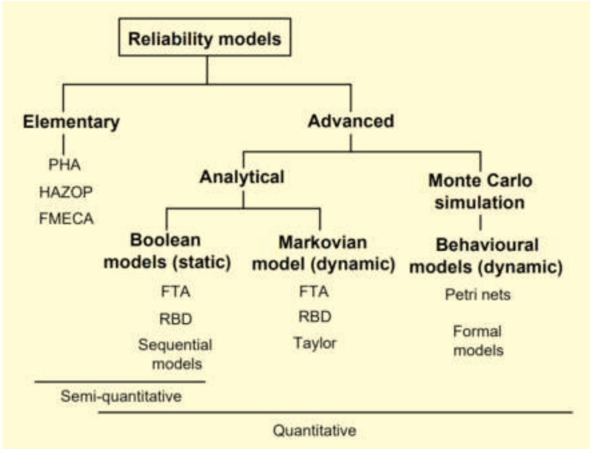


Figure 6. Reliability assessment methods

Indian nuclear power establishment indicate 6% failure probability in starting the emergency systems involving trained personnel [8].

Reliability

The overview of the qualitative and quantitative reliability analysis methodologies is represented in **Figure 6**.

The elementary methods for reliability analysis including Process Hazard Analysis (PHA), Hazardous Operations (HAZOP) studies and Failure Mode Effect and Criticality Analysis (FMECA) utilise a set of organised and systematic assessments to identify potential hazards and making decisions for improving safety (**Figure 7**).

According to MIL-STD-1629, FMECA is a procedure by which each potential failure in a system is analysed to determine the results or effects thereof on the system and operations, and to classify each potential failure mode according to its consequence and severity.

Quantitative reliability estimations using numerical methods based on field failure data and published failure models serve as a yardstick for comparing alternate technologies, continuous improvements and maintenance

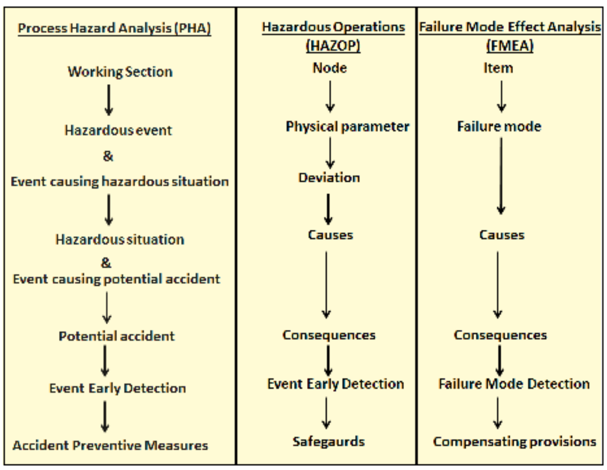


Figure 7. Principles of PHA, HAZOP and FMEA

planning of the time-critical systems. The reliability of a system is defined in Failure-In-Time (FIT), is usually represented as λ, and expressed in failures per billion hours.

Given the number of failures and the cumulative operating period, λ is calculated as (Number of failures/ Total operating time in hours) x 10^9. For the system/ component with a failure rate of λ, the probability of failure (PoF), Q(t) in % in a period t is computed based on the following relationship,

$$Q(t)=1-e^{-\lambda t}$$

Estimates of failure rates are based on engineering and historical data and the stated probabilistic estimate includes a measure of uncertainty. The initial estimates of PoF could be made by comparison of similar equipment, historical data (heritage), handbooks and expert elicitation.

Advanced analytical reliability models (**Figure 6**) based on Boolean, Markov Graph (MG) and Monte-Carlo (MC) simulations use Probabilistic Risk Assessment (PRA) technique with system/component failure rates as

> *The modern use of the word, 'reliability' was defined by the U.S military in the 1940s, characterising a product that would operate when expected and for a specified period of time*

inputs. PRA is a comprehensive, structured and logical analysis method used for identifying and assessing risks in complex technological systems for the purpose of cost-effectively improving their safety and performance. In static models, including Fault Tree Analysis (FTA) and Reliability Block Diagram (RBD), the relationships linking its state to the states of its components do not depend on time.

In dynamic models, the system jumps from state to state after random delays related to failure, repair or any other event and this is modelled using stochastic methods such as Markov [9].

The Markov process belongs to state- transition models and can be graphically represented as Markov graph (MG) where the system states and the transition from state to state are represented. Markov graph when combined with FTA or RBD are called FTA/RBD-driven MG. They are used to model small complex systems. It has certain limitations that the size of the model grows exponentially with the number of states (2^n), where n is the number of components.

If there are 10 components, it has 1024 states and system with 30 components shall have 1 billion states. The limitation in the MG can be overcome with PetriNet where the size of the model is linear with the number of components. PetriNet is a directed bipartite graph in which models represent transition and places.

The MC simulation is based on generation of random numbers used to calculate random delays participating to particular trajectories of the modelled stochastic process. When plenty of trajectories have been simulated, then the probabilities of interest are estimated by simple statistical calculations.

The secret of the powerfulness of the MC simulation is that, during the simulation, the number of potential states does not matter as only scenarios with highest probabilities are actually observed.

Operational errors could be reduced by training the operating personnel using simulators, improved ergonomics, hardware interlocks and software interlocks

Conclusions

The reliability of the propulsion, protection and life support power systems in an Integrated Electric Power System needs careful evaluation during the design and operational phases, as the ramifications of non-operation or mal-function could be catastrophic. Hence, RAMS-centred system engineering with a reasonable reliability, safety and efficiency trade-off is essential for multi-megawatt vessel power systems.

The second part of the article discusses the advancements in protective relaying; its application in subsystem protection and the configuration requirements for meeting various levels of IEC 61508 Safety Integrity Level using reliability analysis software with field failure data as inputs. The approach towards ensuring seamless power system protection coordination and fault discrimination shall be explained using the current-time characteristic curves.

The third and the fourth parts of the article describes the importance of regular condition monitoring of the transformer oil, advantages of ungrounded neutral, recent developments in online insulation monitoring techniques and the need for higher insulation voltage to withstand ground faults, the stringent quality needs for marine grade power cables, their integrity monitoring and the ampacity de-rating for multi-layered configurations with the help of finite element analysis tools, various possible induction motor failure modes, off-line and on-line condition assessment methods, healthiness monitoring interval for the emergency generators and uninterrupted power supplies to comply with the vessel safety integrity level requirements.

In the fifth and the sixth part, taking into consideration the importance of reliability of the propulsion systems during vessel critical manoeuvres and operations, the methodologies for reducing the failure rate of the active-front-end high power density variable speed propulsion drives by incorporating dynamic redundancy in the inverter power electronics and the reliability assessment for various classes of dynamic positioning systems shall be explained. Discussions on the electrical design considerations for the ship-powered intervention systems are also included in the sixth part.

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About the author

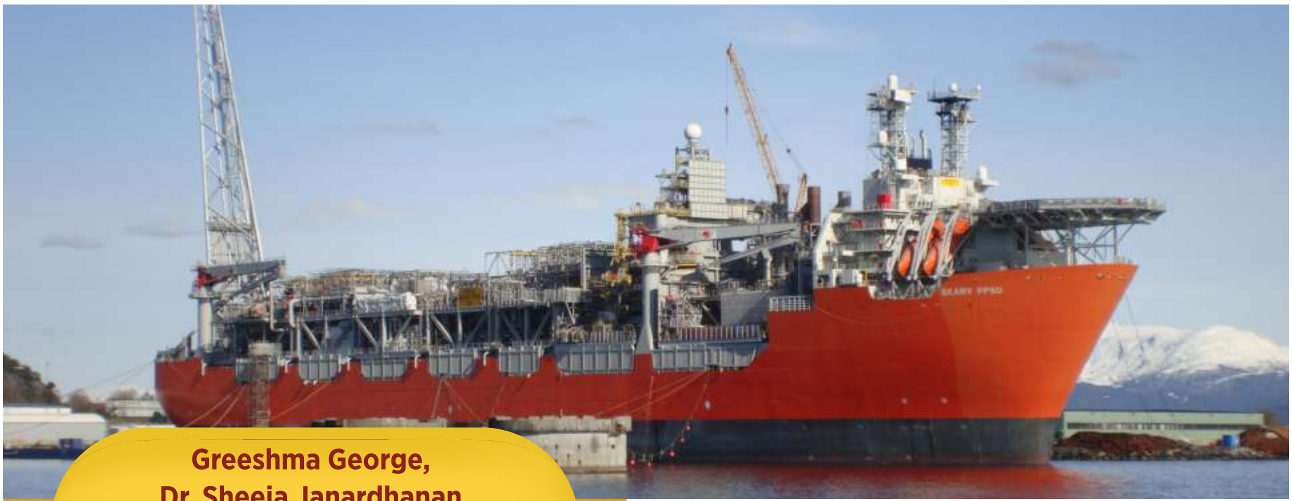
Dr. N. Vedachalam is currently a Senior Scientist with NIOT, Chennai. His 26 years of experience includes industrial power, process, offshore, and subsea domains at Aditya Birla Group and GE Power Conversion & Alstom-Converteam in France. His technical exposure includes development of multi-megawatt power and control systems for deep-water enhanced hydrocarbon recovery systems of Ormen Lange subsea compression pilot with GE; Ocean renewable energy systems including ocean thermal energy conversion, wave energy systems & remotely operated vehicles with NIOT; subsea grids for tidal energy farms for Paimpol Brehat, France and industrial power generation, utilisation and boiler control systems in process industries. He has more than 85 publications in indexed journals, holds an international and two national patents in subsea robotics and subsea process. He is a recipient of the National Meritorious Invention Award in 2019 for the development and usage of underwater robotic vehicles. He is presently a Member of Bureau of Indian Standards and was the Secretary of IEEE Ocean Engineering Society- India Chapter and Executive Member of Marine Technology Society-India Section. He is a regular contributor to MER.

Email: veda1973@gmail.com

References

1. Review of maritime transport, 2019, UNCTAD/RMT/2018, ISBN 978-92-1-112928-1, https://unctad.org.
2. Tae-Hwan Joung, Seong-Gil Kang, Jong-Kap Lee &JunkeonAhn, The IMO strategy for reducing greenhouse gas emissions and its follow-up actions towards 2050, Journal of International Maritime Safety, Environmental Affairs, and Shipping, 4:1, 1-7, DOI: 10.1080/25725084.2019.1707938.
3. IEEE 45.1-2017 - IEEE Recommended Practice for Electrical Installations on Shipboard—Design, https://standards.ieee.org/standard/45_1-2017.html
4. Offshore and onshore reliability data, https://www.oreda.com/
5. International Council on System Engineering, https://www.incose.org/systems-engineering
6. International Electro-Technical Commission (IEC). (2000). IEC 61508. Functional safety of electrical/electronic/programmable electronic safety-related systems. Geneva: IEC, 12pp.
7. DNV rules for ship classification, Part 4 – Chapter 8, Electrical Installations, 2018.
8. K. Subramaniam, A perspective on human reliability analysis, Bhaba Atomic Research Centre, 2000. https://www.osti.gov/etdeweb/servlets/purl/20134625,
9. Jean Marc Signoret, Leroy Alain, Reliability assessment of safety and production systems, 2021, Springer, ISBN 978-3-030-64708-7

A NUMERICAL STUDY ON STRUCTURAL RESPONSE OF FPSO UNDER WAVE INDUCED MOTIONS



Greeshma George,
Dr. Sheeja Janardhanan

Abstract: FPSO (Floating Production, Storage and Offloading) is generally a ship used by oil and gas industry for performing a multitude of tasks and is moored to the ocean bed for the extraction of oils and hydrocarbons. Due to continuously varying cyclic load, FPSO undergoes progressive and localised structural deformations leading to fatigue damage. Structural analysis of the FPSO is important to establish the strength and stability of the structure. A moored FPSO generally has three degrees of freedom viz. heave, roll and pitch, under following sea conditions. In this paper, a numerical study on the FPSO has been conducted with the help of CFD (Computational Fluid Dynamics) analysis under calm sea-state and the subsequent structural response of the system has been calculated by finite element method. CFD studies have high potential in determining the effect of any complex fluid loading with reasonable degree of accuracy. Geometric modelling and meshing have been carried out in ANSYS ICEM CFD.

An unstructured grid system has been used here and the prescribed motions on the hull in heave, roll and pitch have been brought in using user defined function (UDF) module of the commercial CFD solver, FLUENT. Air water interface has been captured using volume of fluid method.

The lift and drag forces are calculated from the simulations. Fluid forces have been validated against their analytical counterpart using Linear wave theory and Strip theory. Structural response of 3D hull has been predicted in ANYS Workbench with the forces determined from the CFD solver as input.

Equivalent stress distribution and total deformations of the structure have been studied using static analysis. Understanding the behaviour of structure under various motions provides an insight and guidance to the design calculations of the FPSO in order to withstand fatigue loading.

Keywords: FPSO, CFD, Pitch, Heave, Roll, Lift, Drag, Structural Response

I. INTRODUCTION

FPSO (Floating Production Offloading and Storage) is generally a ship use for the storage of hydrocarbons and oils. It is a large structure and highly technical as shown in **Figure 1.** It performs a multitude of tasks and can act in a wide range of water depths and environmental conditions, especially in harsh environments.

It is the best developed system in oil production industry. From the existing well centres, FPSOs take oil and through the injection lines, the oil is pumped to the storage units. Later the oil is offloaded to the tankers. FPSO is acted upon by repeated loads [2]. The FPSO is acted upon by wave, wind and other environmental loads such as ice in polar regions. Regular inspection and strength analysis is very important [1]. Due to the cyclic loads, it can undergo progressive and structural damages.

Understanding the strength and stability is a very important criterion for fatigue design. The sea state condition, in which the FPSO acts, cannot be, predicted so the design of this structure is complicated and very challenging for engineers. Due to varying loading and unloading cycles, fatigue assessment of the structure is very important.

From the existing well centres, FPSOs take oil and through the injection lines, the oil is pumped to the storage units.

Wu, have done a noticeable work on the total deformation and equivalent stress caused by still water and vertical wave-induced bending moments for a specific FPSO using finite element analysis .

Further, based on cumulative fatigue damage theory and Miner ruler, an empirical formula is proposed to calculate fatigue damage accumulation of FPSO so as to predict the fatigue life of FPSO. Kannah, conducted an experimental investigation on dynamic response of FPSO under regular wave conditions and frequencies. Surge, heave and pitch motions are measured. No much work has been done considering the structural behaviour of FPSO using a CFD input of fluid loading during motions. In this paper structural response of FPSO is computed for fluid loading under different motions for a range of frequencies and fatigue life is estimated.

The objective is to compute the structural response of FPSO under heave, pitch and roll motions under calm sea state and to predict the fatigue life.

Generally, a floating body such as a ship has six degrees of freedom surge, heave, sway, pitch, roll and yaw[4]. As a moored structure, it has only three degrees of freedom that is heave, pitch and roll. The objective is to compute the structural response of FPSO under heave, pitch and roll motions under calm sea state and to predict the fatigue life. Performing the structural response improves the reliability of designs.

II. NUMERICAL METHODOLOGY

Computational Fluid Dynamics (CFD) is the best method to analyse fluid interactions with the structure especially when the structure is undergoing wave-induced motions. The details of FPSO are shown **Table 1**. The FPSO has been scaled down in the simulation (Scale ratio = 1:30)

Figure 1: A FPSO in the ocean

A. Geometric Modelling and meshing

The 2D model of the ship has been created using ANSYS ICEM CFD. **Figure 3** and **Figure 4** show the meshed model of the FPSO. 2D model was also created to find out the behaviour of the ship hull towards the wave simulation. The domain extends are 2L from the inlet boundary, 3L from the outlet and IL each from the top and bottom boundaries. Meshing is carried out as patch independent with a maximum mesh size of 0.6 units. Triangular elements with a minimum size of 0.005 in the y direction are chosen as this value satisfies the CFL criteria. Fine mesh is created around the hull portion in order to capture the air water interface. Modelling and meshing has been carried out in front and side views of a ship. This facilitates simulation of heave (sinusoidal z-translation in x-z plane), roll (sinusoidal rotation about x-axis in y-z plane) and pitch (sinusoidal rotation about y axis in x-z plane). Modelling and meshing in these views are shown in **Figure 2** to **Figure 5**.

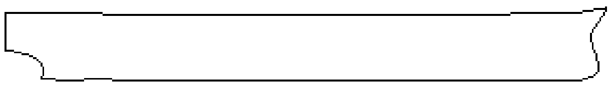


Figure 2: Side View

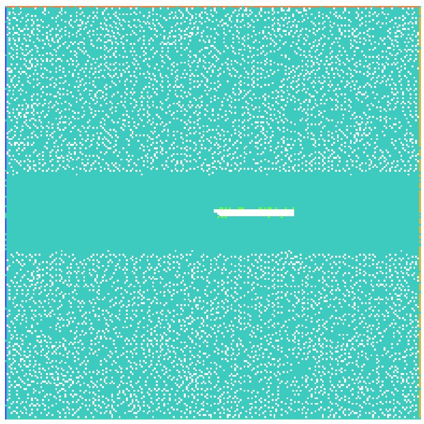


Figure 3: Side view meshed

TABLE I: FPSO PARTICULARS

DESCRIPTION	DIMENSION
Length	248 m
Breadth	42 m
Depth	27.1 m
Draft	21 m
Freeboard	7.1 m

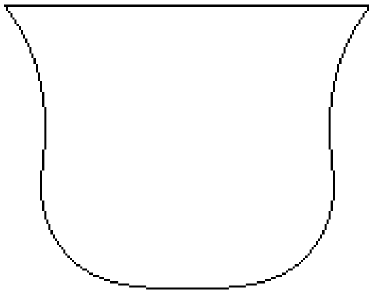


Figure 4: Front view

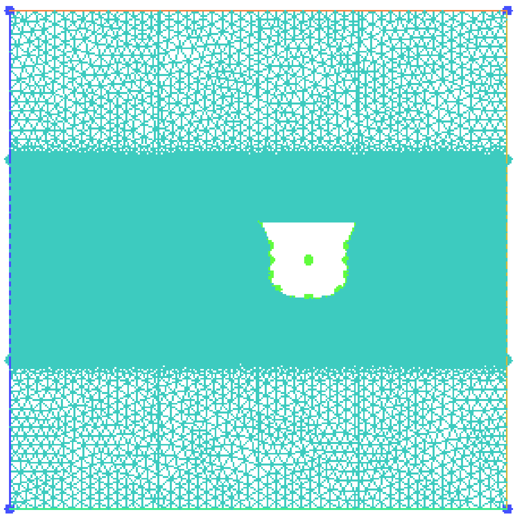


Figure 5: Front view meshed

B. CFD Simulations and Results

ANSYS Fluent 18.1 is launched with a transient and pressure- based solver. Gravity is activated in the negative y-direction. Volume of fluid method is adopted for modelling the air-water interface. It is a free surface tracking technique for effectively capturing its deformations. The boundary conditions for present study are given in **Table 2**.

The boundary conditions represented in Table II are typical to a tank. Hence the simulations are performed in a numerical tank. Dynamic mesh scheme is adopted with smoothing and remeshing. A user-defined function (UDF) is used to describe the motion of the ship. The UDF is a C program which specifies the boundary conditions and imposes prescribed motions on the hull. The body motions follow the sinusoidal function [6] for velocity as given in Eq. (1)

TABLE 2: Boundary Conditions

Boundary	Type
Inlet	Slip wall
Outlet	Slip wall
Sky	Slip wall
Seabed	Slip wall
Hull	No slip wall

$$r = r_a \cos \omega t \quad (1)$$

ω is frequency of oscillation in radians per sec is 0.5rad/s. For the wave generation the simulation was done for a certain time step. *r* is the time dependent velocity and r_a is the velocity amplitude. The time step is computed such that the CFL criteria are satisfied. The time step here is 0.001s.The time period is calculated as shown by Eq. (2).

$$T = \frac{2\pi}{\omega} \quad (2)$$

T is the time period I seconds. The computational runtime for the analysis was 37 seconds, corresponding to 3 cycles for frequency 0.5rad/sec and the amplitude of lift and drag forces of steady state oscillation condition are recorded. Simulation for pitching motion for 0.5 rad/sec is shown in **Figure 6.**

The up and down motion of ship along x axis is simulated using ANSYS FLUENT. Motion amplitude is 0.104 radians.

Drag force from CFD analysis is 1726.05N/m and lift force from CFD analysis is 11188.1 N /m. Simulation for rolling motion for 0.5 rad/sec is shown in **Figure 7**.

Rolling is, the rotation about x axis. Motion amplitude is 0.18 radians. Drag force from CFD analysis is 0.011N/m and lift force from CFD analysis is 0.002 N /m. Simulation for rolling motion for 0.5 rad/sec is shown in **Figure 8**.

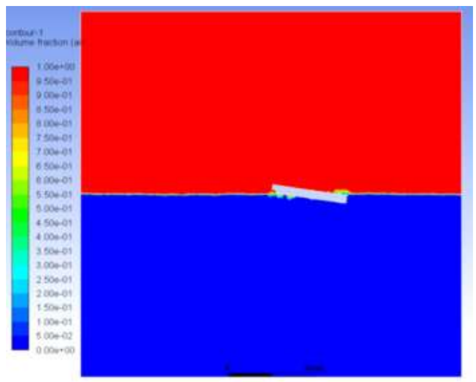


Figure 6: Simulation of pitching motion of FPSO at 0.5rad/sec

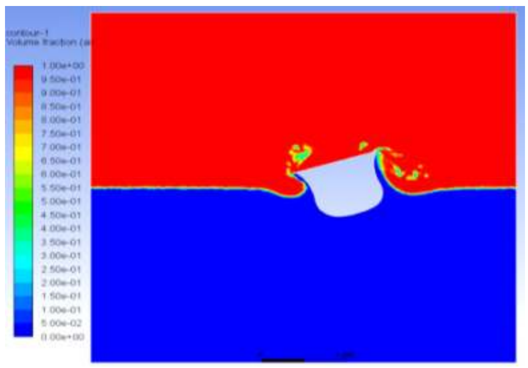


Figure 7: Simulation of rolling motion of FPSO 0.5rad/sec

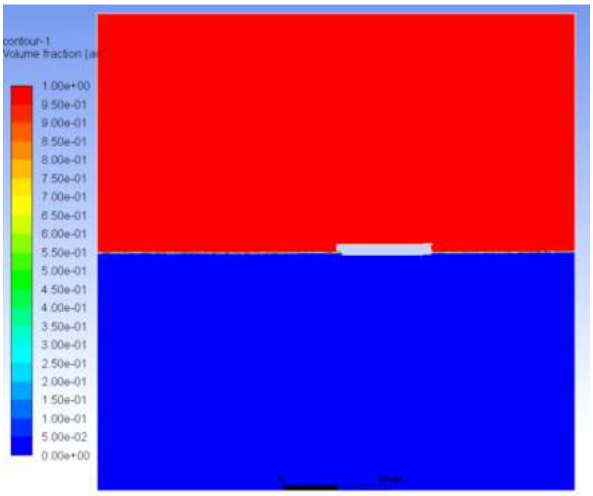


Figure 8: Simulation of heaving motion of FPSO 0.5rad/sec

The linear vertical up and down motion. Motion amplitude is 0.1 radians that is taken as the height of the ship to be heaved. Drag force from CFD analysis is 59.6 N/m and lift force from CFD analysis is 18028.73 N /m.

In order to predict realistic wave loading, a 3D model has been created in ANSYS ICEM CFD with the parameters mentioned in Table I. The model is created with help of points, curves and surfaces. The 3D model is then imported to structural solver and the forces are imposed. **Figure 9** shows the 3D model.

C. Analytical Method

The forces from CFD are verified analytically by means of linear wave theory. The theory assumes that the flow is irrotational and inviscid. The theory is used for small amplitude waves for two-dimensional bodies. Total force is the summation of static and dynamic force [6].Drag force is calculated from the Eq. (3).

$$F=\left\{\int_{-z_1}^{-z_2} \rho g z \, dz + \int_{-z_1}^{-z_2}\int_0^l (\rho g a e^{kz} \cos(\omega t - kx))dxdz\right\} b\times c \quad (3)$$

Where

F= Drag force in N
P= Pressure
ρ = Water density
g = Acceleration due to gravity
z_1 = vertical coordinate in left side
z_2 = vertical coordinate in right side
a= wave amplitude
k = wave number
x = horizontal coordinate
ω = wave frequency
λ = wave length
t = time at any instant
b= width of ship
l= length of ship at bottom
c = Block coefficient

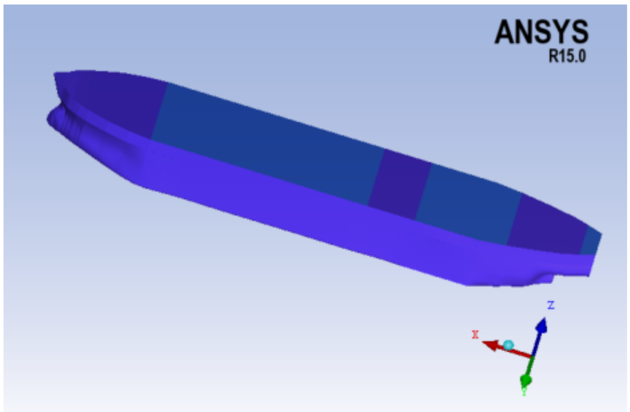


Figure 9: 3D model of FPSO

In case of pitching motion, drag force is 1781.5 N/m . The numerical results of drag force for pitch varies 3% .In case of heave the static force is zero. The dynamic force obtained from the equation is 58.42N/m. The numerical results for heave vary 2.5% from analytical results and the variation is within permissible limits.

The lift force due to pitching and heaving is computed with the help of strip theory. In this theory ship is assumed to be divided into many strips .The two-dimensional flow problem is found by integrating the forces or hydrodynamic characteristics along the ship knowing the mass and radiation, and damping coefficients for each strip. Assume that the ship is forced to oscillate in calm water with the amplitude,and the angular frequency,. The vertical reaction force acting on the body from the water can be computed after integrating the two dimensional reaction forces, along the ship [6]is calculated from the Eq. (4) and (5).

$$\eta = \hat{\eta} \cos(\omega t) \quad (4)$$

$$F = -(A_{33} + m)\ddot{\eta} - B_{33}\dot{\eta} - C_{33}\eta_3 \quad (5)$$

Where F represents the lift force, m the mass and the coefficients A_{33}, B_{33} and C_{33} are the integrated or summed quantities along the ship. Theoretically value of lift force in case of heave is 17602.73 N/m and for pitch is 12014.5N/m. The numerical results of lift force vary 2.3% in case of heave and 6.87% in case of pitch from analytical results. The variation is due to use of coarser grid, negligence of viscous effect.

III. STRUCTURAL RESPONSE COMPUTATION

The aim of structural analysis and design is to develop a structure that will be able to withstand all loads and deformations. FPSO is designed for life with a suitable margin of safety. FPSO as it is subjected to harsh environment its safety has to be thoroughly checked. ANSYS provide many comprehensive simulations sets and solve wide range of problems[5].3D model of the FPSO from ANSYS ICEM CFD is imported to ANSYS Workbench 15.0 for structural analysis is shown in **Figure 10** and meshed model of structure is shown in **Figure 11**.

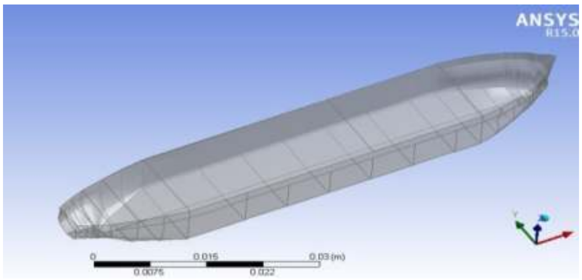


Figure 10: 3D model in ANSYS Workbench

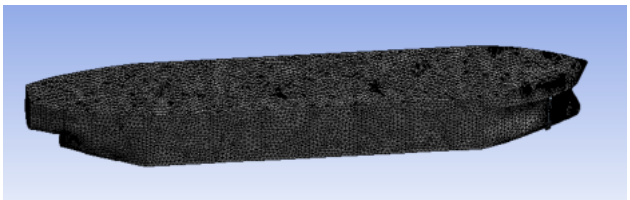


Figure 11: 3D meshed model in ANSYS Workbench

Static structural analysis is taken as load is not varying with respect to time. High grade strength steel is taken as material for FPSO. The thickness provided is 20mm. The modulus of elasticity and Poisson's ratio for the ship building grade steel is 2.1×10^{11} N/m^2 and 0.3 respectively. The tensile strength of steel is 250MPa.Forces are provided transversely and axially. Drag force is applied axially and lift force is applied transverse to the bottom of hull. Total deformations and stresses are also shown in figures below respectively indicating the region of higher deformation and stress. Two cases have been taken to carry out the ship structural analysis that is pitching and heaving. Because the two loading conditions are different. Structural responses due to pitching and heaving motions are shown below.

A. Response due to pitching effect

The lift force 11188.1 N/m is applied vertically upwards on the bottom surface and drag force 1726.05N/m is applied axially against the flow direction. Total deformation diagram and equivalent stress diagram are shown in **Figure 12** and **Figure 13**.

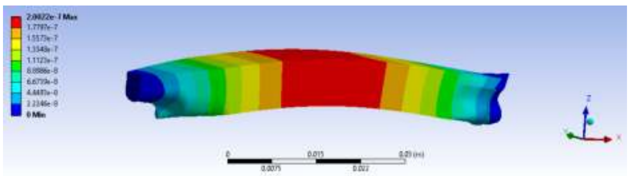


Figure 12: Total deformation diagram under pitching effect

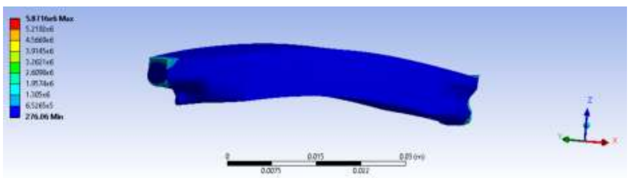


Figure 13: Equivalent stress diagram under pitching effect

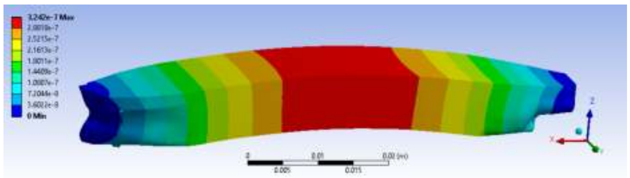


Figure 14: Total deformation diagram under heaving effect

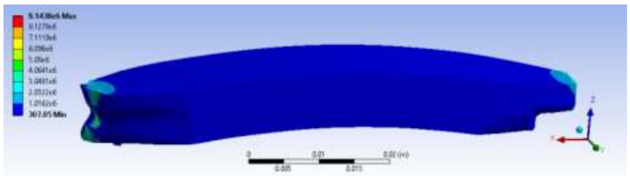


Figure 15: Equivalent stress diagram under heaving effect

B. Response due to heaving effect

The lift force 18028.7 N/m is applied vertically upwards on the bottom surface and drag force 59.5N/m is applied axially against the flow direction. Total deformation diagram and equivalent stress diagram are shown in **Figure 14** and **Figure 15**.

The midship section shows the maximum deformation in all the cases so it has to be strengthened more specially with stiffeners. The deformation is maximum in the case of heaving and minimum in the case of pitching. The stress is also maximum for heaving and minimum for rolling. The yield stress of material is 250MPa and the obtained values are within the limit. In the case of rolling drag and lift force obtained is very less and so it is neglected.

IV. CONCLUSIONS

Structural behaviours of FPSO under calm sea state conditions are analysed. CFD simulations are carried out for heave, pitch and roll motions of FPSO. Deformations in air water interface is captured and lift and drag forces are calculated. Forces from CFD are comparable with linear wave theory and strip theory. In this paper total deformation and equivalent stress diagram caused by heaving and pitching are studied by finite element analysis.

Rolling is neglected since the forces obtained are less. The forces effect for rolling motion is in a negligible level. The FPSO has maximum stress and deformation under heaving motion. The stress obtained is within the yield stress of material. CFD and structural response computation method adopted here proved to be a better method in analysing the FPSO behaviour.

SCOPE FOR FUTURE WORK

Structural response of FPSO under various sea states are to determine and analyse the maximum stresses and deformations .Fatigue life is to be estimated using spectral analysis method for various sea states.

ACKNOWLEDGEMENT

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References

1. Lei yu et al., (2017)" Study on the remaining fatigue life of FPSO based on spectral analysis", *International Conference on Ocean, Offshore and Arctic Engineering*.
2. Yingguang Wang, (2010)" Spectral fatigue analysis of a ship structural detail – A practical case study, *"International journal of Fatigue 32 (310-317)"*
3. Lei Wu, et al., (2017) "Interaction and combination method for estimation of still water and wave-induced bending moments on FPSO", *World congress on Advances in Structural Engineering and Mechanics*.
4. Damitha Sandaruwan et al., (2010), "A Six Degrees of Freedom Ship Simulation System for Maritime Education", *The International Journal on Advances in ICT for Emerging Regions 2010 03 (02) :34 – 47*.
5. Emil Mathews et al., (2013), "Fatigue life estimation of ship structure", *International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May*.
6. Lars Bergdahl, (2009) "Wave-Induced Loads and Ship Motions" Department of civil and environmental engineering *division of water environment technology,* Chalmers university of technology.
7. T. Rajesh Kannah et al., (2006) "Experimental study on the hydrodynamics of a Floating, Production, Storage, and Offloading", *Journal of Waterway, Port, Coastal, and Ocean Engineering, Vol 132, No. 1*.

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OBITUARY

ARUN SENGUPTA

Shri. Arun Sankar Sengupta was born in 1933 in Barisal town, East Bengal (now Bangladesh), and was the elder brother of renowned journalist Late Shri. Barun Sengupta.

He studied in Cossimbazar Polytechnic and Scottish Church College, Kolkata, and then trained to be a marine engineer from DMET, Calcutta, passing out in 1955.

He joined India Steamship Company Ltd., as Engineer Officer and then obtained his First Class Certificate (Steam & Motor) in the year 1960. He served on ships from 1955 to 1961.

He then worked with Lloyd's Register of Shipping from 1961 to 1997 – a long 36 years – rising to be Country Head and South Asia Head of LRS, covering India, Bangladesh, Sri Lanka and Maldives. He was very closely connected with ship building, ship repair and related developments in India and abroad during this period.

After retirement in 1997, Shri. Sengupta joined The Shalimar Works (1980) Ltd., and then became the Chairman of the Board of Directors. He also became an Advisor to the Indian Navy and five large public sector shipyards. During this time, he contributed notably to the achievement of higher productivity and quality of ship building. He was also instrumental in the development of inland water transport in India, helping to launch an ambitious program of 15,000 small ships and barges for use in the National Waterways.

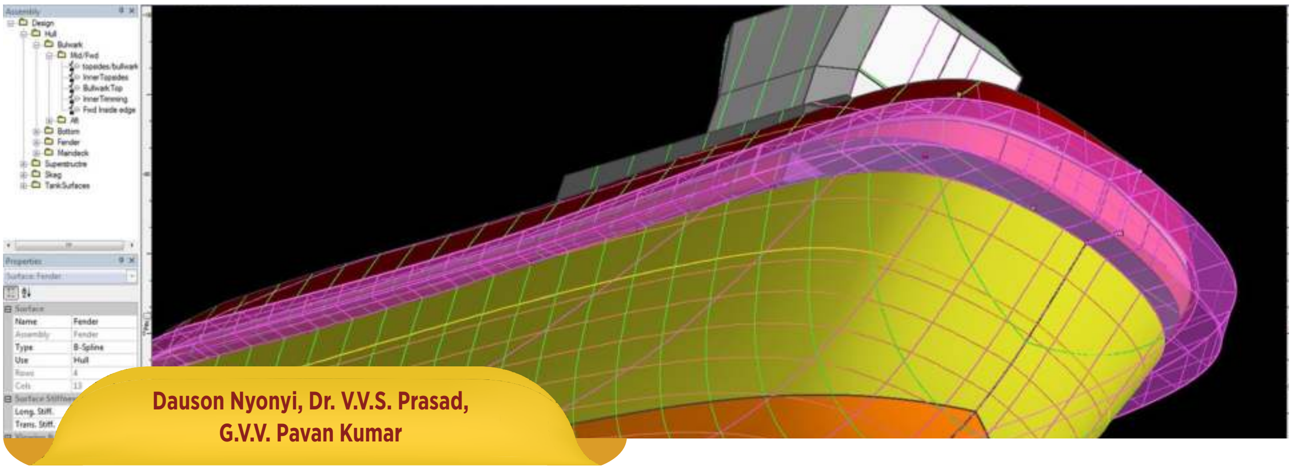
He was a Fellow of the Institution of Engineers (India) and the Institute of Marine Engineers (India). He was the Chairman of the Organising Committee of the Diamond Jubilee Celebrations of DMET in 2008-2009. In his lifetime, he received numerous honours and awards in the field of Marine Engineering. The Kolkata Branch of the Institute of Marine Engineers (India) felicitated him with their annual Citation of Honour in 2020.

Shri. Sengupta, was a very respected and well-loved member of the marine engineering profession. His very soft and gentle nature endeared him to all who came across him. He could often be seen having tea in the evenings at his beloved Calcutta Club.

This giant of the profession passed away peacefully on 24 August 2021 at his country residence in Boral, south of Kolkata, aged 88. He leaves behind his wife Krishna, daughter Srabani, and grandchildren Tanya and Surjo.

May his soul rest in peace.

STABILITY ANALYSIS OF 10,000 DWT MULTI-PURPOSE CARGO VESSEL USING MAXSURF SOFTWARE



Dauson Nyonyi, Dr. V.V.S. Prasad,
G.V.V. Pavan Kumar

ABSTRACT: This paper presents a ship design and stability analysis of a 10000 DWT Multi-Purpose Cargo Vessel (MPCV) with the service speed of 15knots. The proposed MPCV was designed to meet the demand of transporting different kinds of commodities from one port to another or from one continent to another with greater amount of cargo tonnage e.g., Visakhapatnam Port Trust (India) to Dar-es-Salaam Port (Tanzania).

The computer aided ship design (CASD) software was employed to perform the vessel design process and stability analysis. The Maxsurf package as the Naval Architecture tool is one of the packages selected to be used for ship model hull form design and carrying out the stability analysis. The stability analysis was conducted under Intact stability criteria IMO A.749 (18) Ch. 3.1.2.1-4. The Stability assessments were performed to verify whether the vessel stability complies with international standards. The following types of stability were evaluated: up-thrust, large angle, KN value and limiting KG value. The stability results were recoded and it shows that the general KN value justified well (good), GZ curve has large area under the curve indicating good stability characteristics of the MPCV.

Key words: Multi-purpose Cargo Vessel, Merchant vessel, ship design for Stability analysis, and Maxsurf Package.

1.0 Ship Particulars

The goal of this paper is to provide the education knowledge for the preliminary design of multi-purpose cargo vessels (MPCV) for determining the steady optimal ship characteristics and stability assessments of a vessel's stability [2]. Practical principal data provided were the carrying capacity of 10,000dwt and service speed of 15konts at open water and other type of physical characteristics are general vessel shape [3] [4] [5]. From these parameters, we can initiate the other main parameters such as Length of water level, breadth moulded, depth, draft and vessel displacement [6].

Principle particulars of MPCV

Length overall (LOA):	140m
Length to Waterline (LWL):	137m
Length between PP(LBP):	130m
Breadth amidships (B):	21m
Draft (T):	9.5m
Depth (D):	11m
Speed:	15Knots
Deadweight tonnage:	10,000 ton
Gross Tonnage:	7780 ton
TEU:	686

Power: 7340.79kW (Single Screw Engine)

1.1. Ship hull form line plan

The ship hull form is the watertight enclosure of the vessel, which protects the cargo hold, machinery and accommodation spaces of the ship form from weather, flooding, and structural damage [7]. The type of ship operations and purpose it determines the hull dimensions, shapes and form which also influence the cargo, accommodation, machinery arrangement [11].

Ship line are needed to describe the surface, and the ship's form must be shaped to accommodate all internals and must meet limitations of buoyancy, stability, speed, power, sea keeping, and must be "build able" [9].

The complete lines plan of a ship is arranged by placing the profile view on top **Figure 1**, with the plan view just below **Figure 2**, and the body plan **Figure 3**, as shown. The lines plan provides for the foundation of developing not only the three-dimensional hull model, but

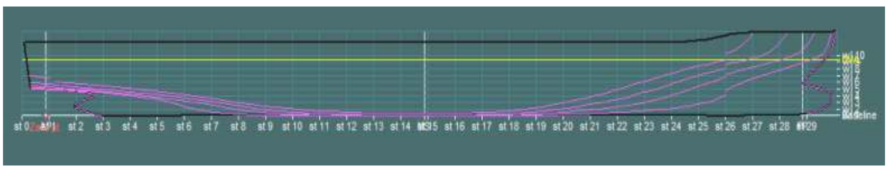


Figure 1: Profile View

also developing frame-wise structural drawings, general arrangement, and loft drawings at the shipyard [7] [8].

1.2. Three Dimensional of Ship hull form

Figure 4, shows a lines plan of a modern hull form.

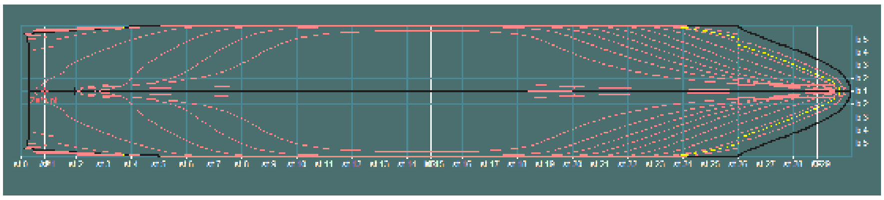


Figure 2: Plan View

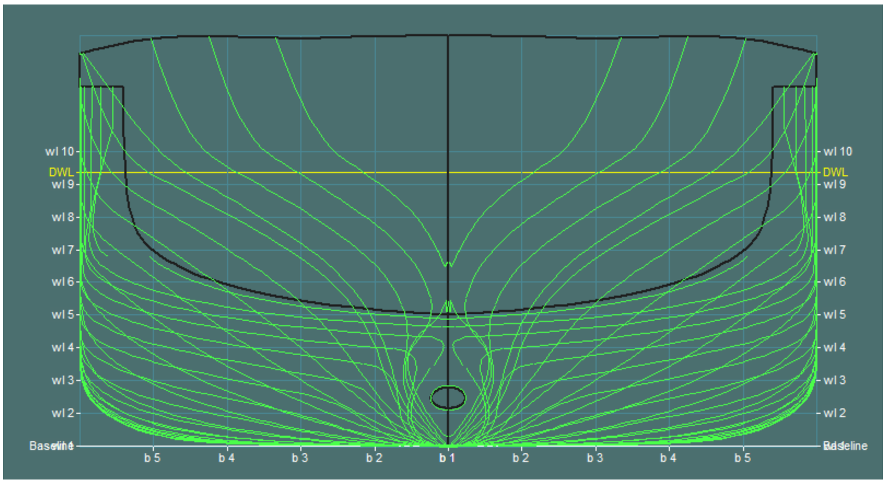


Figure 3: Body plan line

Figure 4: 3D Model hull form

Figure 5: Tank and Bulkhead arrangement

Table 1: Division of Compartments: -

Component	Frame Number	Spacing (mm)	Length (m)
Aft peak tank	-4 to 7	450	4.95
Steering Room	8 to 17	650	5.85
Engine room	18 to 44	730	18.98
Cargo hold-5	45 to 71	730	18.98
Cargo hold-4	72 to 98	730	18.98
Cargo hold-3	99 to 125	730	18.98
Cargo hold-2	126 to 152	730	18.98
Cargo hold-1	153 to 179	730	18.98
Fore peak tank	176 to 206	420	12.6
Total design vessel water length			137.28

1.3. Estimation of Compartment and Frames

The ship capacity plan is part of the process of determining the cargo volumes in holds (positioning the bulkheads) and the number of frames which help in disposition of tanks to their position of centre of gravities [12]. The spacing of the frames helps the design to estimate the volume (position/number of bulkheads etc.) [13].

Transverse framing system is employed on this general cargo ship design and its number and spacing are used to estimate the number of bulkheads [7]. Frame spacing specified by classification societies for this design the IR Class Part3, Section 1:3 will be used. **Table 1** gives the insight on the number of frames and Bulkheads which are used in vessel general arrangement [12].

1.3.1 Bulkheads and Tanks Arrangement

During this stage, a Preliminary design is used to outline the specifications and a short description of the vessel [11]. Maxsurf software tool are used to illustrate the main parameters and components as shown in **Figure 5**. The dimensions of the bulkhead are taken from **Table 1** followed by the locations of fore peak tank, aft peak tank, Engine room, steering room, Cargo holds, Crane, fore bow thruster and Ballast tanks [12].

2.0. Maxsurf Software Tool For Stability Analysis

Maxsurf software helps in Naval Architecture studies by providing integrated tools for the hull modelling, optimisation, comprehensive stability, motion and resistance prediction, structural modelling, structural analysis and export to vessel detailing [10]. The MAXSURF Stability 20.00.02.31, will be employed for conducting MPCV design and Stability analysis [10]. Once the general design of the hull form and main dimensions are fixed in modeller, tanks/compartments/structure can be defined and then MPCV stability analysis can take place [15].

2.1. Method of analysis

This section will cover all aspects of the analysis methodology as shown in **Figure 6** [1]. The analysis is carried out in 2 steps. First, the GM (max), GZ-Value,

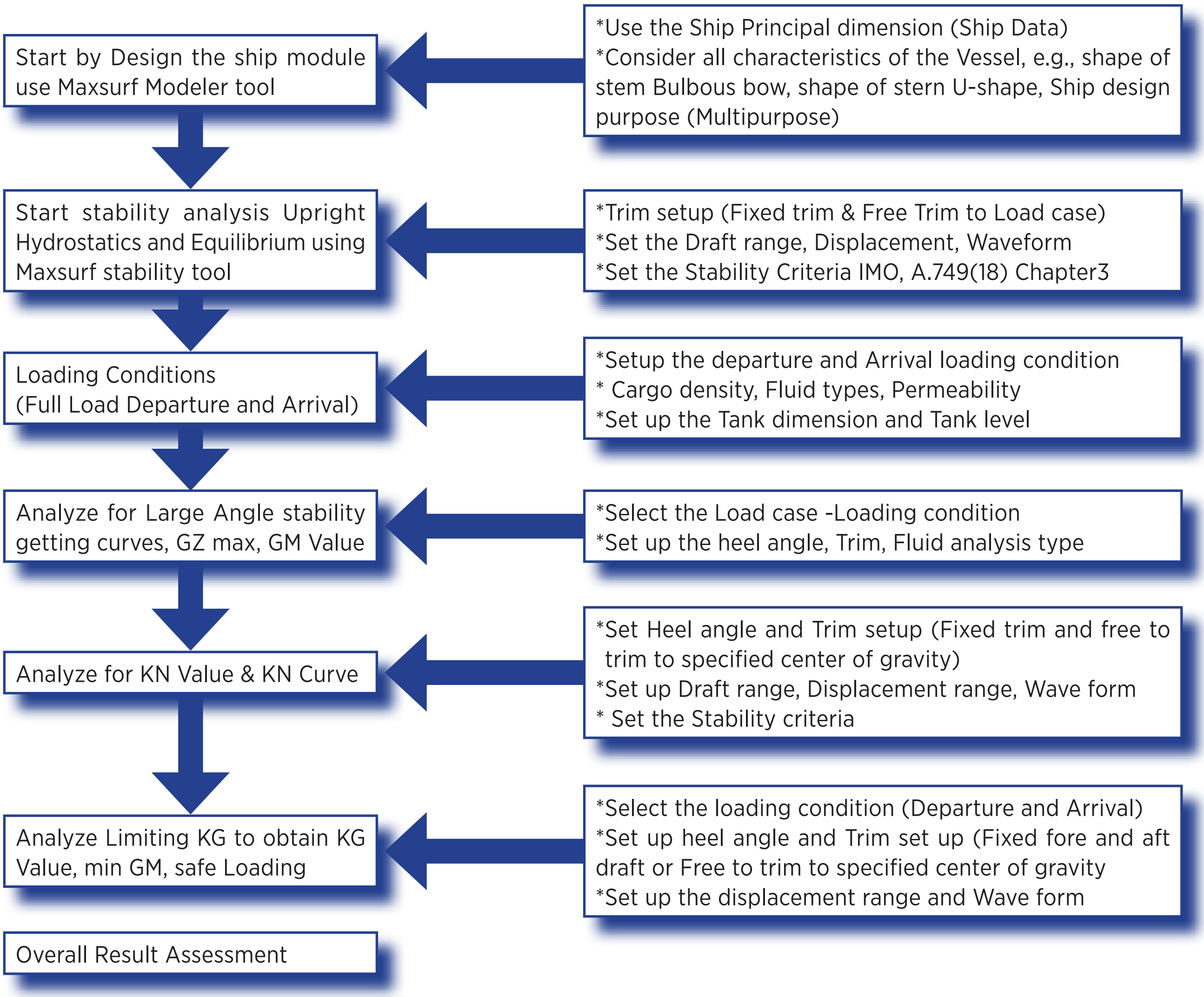


Figure 6: Iterative procedure of the intact stability analysis

limiting KG and KN Value are determined using intact stability rules [11]. The Intact stability analysis will be assessed by the IMO, A.749 (18) Chapter 3.1.2.1-4. Different intact stability loading conditions namely, "loaded departure condition" and "loaded arrival condition" as specified were analysed [1].

2.2 Hydrostatics calculations for MPCV

Stability 20.00.02.31, Damage Case – Intact. Fixed Trim = 1 m (+ve by stern), Specific gravity = 1.025; (Density = 1.025 tonne/m^3), Analysis performed in Sinusoidal waves, Wavelength = 130 m; Wave Height = 3.921 m; Hydrostatic calculations are shown in **Table 2** and **Figure 7**.

2.3. Vessel Stability at Departure Loading condition

The MPCV at a " fully load departure condition", the cargo holds are filled up to 98 % and fuel oil, diesel oil, fresh water are filled up to 95 % of full capacity.

Damage Case - Intact

Free to Trim, Specific gravity = 1.025; (Density = 1.025 tonne/m^3), Fluid analysis method: Use corrected VCG Analysis performed on Sinusoidal waves, Wavelength = 130 m; Wave Height = 3.921 m.

Stability Criteria tested: IMO, A.749 (18) Chapter 3.1.2.1-4, Design criteria applicable to all ship. The following result obtained from **Table 3** was used to plot on the curve as shown in **Figure 8.**

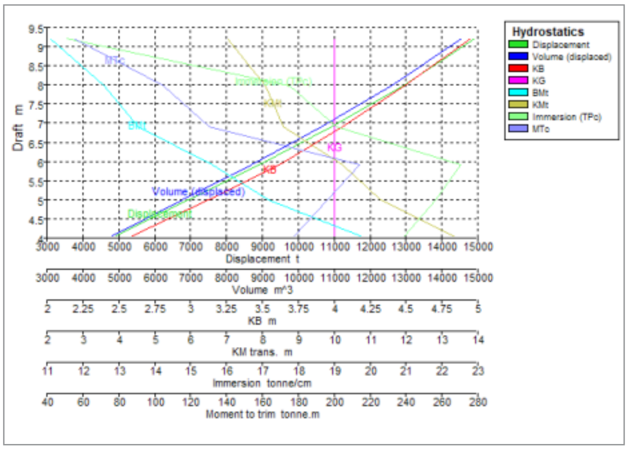


Figure 7: MPCV Hydrostatic curve.

Table 2 Hydrostatic Values

Draft Amidships (m)	4.065	4.996	5.903	6.899	7.988	9.219
Displacement t	4924	6924	8924	10924	12924	14924
Draft at FP m	3.565	4.496	5.403	6.399	7.488	8.719
Draft at AP m	4.565	5.496	6.403	7.399	8.488	9.719
Draft at LCF m	4.150	5.070	5.962	6.856	7.884	9.113
WL Length m	138.1	133.42	133.7	134.5	135.6	132.9
Beam max extents on WL m	18.50	18.5	18.5	18.5	18.5	18.5
Water plane Area m^2	2044.87	2130.2	2198.3	1858.7	1732.0	1125.1
Prismatic coefficient (Cp)	1.071	1.006	0.979	0.944	0.907	0.863
Block coefficient (Cb)	0.495	0.563	0.614	0.643	0.657	0.657
Midship Sect. area coefficient (Cm)	0.462	0.560	0.627	0.681	0.725	0.761
Water plane area coefficient (Cwp)	0.857	0.886	0.915	0.773	0.721	0.468
LCB from amidships (+ve fwd) m	-9.629	-9.897	-9.550	-7.665	-4.996	-2.079
LCF from amidships (+ve fwd) m	-11.084	-9.613	-7.761	5.619	13.440	13.668
KB m	2.593	3.121	3.622	4.057	4.488	4.950
KG m	4.000	4.000	4.000	4.000	4.000	4.000
BMt m	10.740	8.166	6.609	4.535	3.602	2.075
BML m	470.8	369.9	312.0	155.0	105.1	46.8
GMt m	9.259	7.211	6.158	4.533	4.052	3.009
GML m	469.3	368.9	311.6	155.0	105.5	47.8
KMt m	13.332	11.287	10.231	8.592	8.090	7.025
Immersion (TPC) tonne/cm	20.960	21.834	22.533	19.052	17.753	11.532
MTc tonne.m	177.8	196.5	213.9	130.3	104.9	54.9
Trim angle (+ve by stern) degrees	0.4407	0.4407	0.4407	0.4407	0.4407	0.4407

2.4. Vessel Stability at Arrival loading condition

In "loaded arrival condition" the fuel oil, diesel oil and fresh water are assumed to be consumed to 20% of full capacity in transit and the cargo quantity remains as 98% and Sum Tank full to 80%.

Damage Case - Intact

Free to Trim Specific gravity = 1.025; (Density = 1.025 tonne/m^3) Fluid analysis method: Use corrected VCG. Analysis performed on Sinusoidal waves; Wavelength = 130 m; Wave Height = 3.921 m; Wave Phase Offset = 0.95.

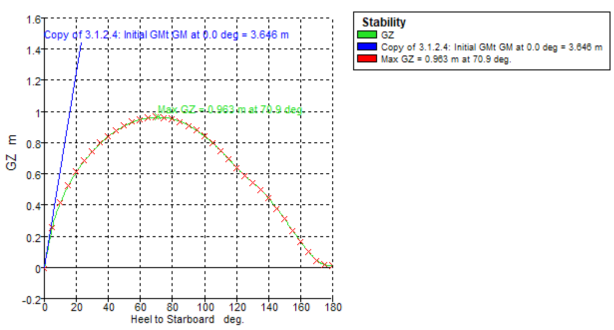


Figure 8: GZ curve at full load departure

Stability Criteria tested: IMO, A.749 (18) Chapter 3.1.2.1-4, Design criteria applicable to all ship. The results obtained from **Table 4** were used to plot the curve as shown in **Figure 9.**

2.5. KN Cross Curves of Stability

It is essential that various Tables for determining the stability of the vessel (for different displacement conditions) are generated against the heel angles [9]. Then the value of KN value (while listing) can be obtained, which will indicate the stability of the vessel to retain its upright position. The Cross curves of stability are a set of curves from which the KN values for a set of heel-angle values at any particular displacement may be read. KN is the righting lever measured from the keel of the vessel [15]. The curve demonstrates the value of KN as the vessel heel at any angle degree due to displacement [9].

The cross curves of stability can be established for any loading condition where KG is already known, values of righting lever (GZ) can be obtained for all angles of heel [15].

The **Figure 10** illustrates on how KN value were obtained. Where the point 'K' represents the keel of the ship, (ϴ) represent any angle of heel, KN is a line distance

Table 3: Full load Departure condition

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	FSM Type
Lightship	1	4923.0	4923.00			60.803	0.000	3.525	User Specified
Cargo	1	8000.0	8000.00			68.000	0.000	4.500	User Specified
Main Diesel Engine	1	100.00	100.000			25.000	0.000	2.000	User Specified
Generators	3	50.000	150.000			15.000	0.000	2.000	User Specified
Crane 1	1	50.000	50.000			45.000	0.000	7.000	User Specified
Crane 2	1	50.000	50.000			95.000	0.000	7.000	User Specified
H.F.O (S)	98%	235.81	231.114	280.751	275.136	27.313	-6.78	5.382	IMO A.749(18)
HFO (P)	98%	235.81	231.114	280.751	275.136	27.313	6.784	5.382	IMO A.749(18)
HFO Daily Service	98%	31.655	31.022	37.685	36.931	27.545	3.743	4.434	IMO A.749(18)
Fuel Oil (s)	98%	113.07	110.813	119.744	117.349	25.207	-3.23	4.542	IMO A.749(18)
Fuel Oil (p)	98%	113.07	110.813	119.744	117.349	25.207	3.228	4.542	IMO A.749(18)
Fuel Daily Service	98%	98.207	96.243	104.000	101.920	25.000	0.000	4.348	IMO A.749(18)
Lube Oil (s)	98%	6.353	6.226	6.906	6.768	17.310	-4.35	3.697	IMO A.749(18)
Lube Oil (p)	98%	6.353	6.226	6.906	6.768	17.310	4.354	3.697	IMO A.749(18)
Hydraulic Oil (s)	98%	4.745	4.650	5.331	5.225	3.033	-6.24	5.514	IMO A.749(18)
Hydraulic Oil (p)	98%	4.745	4.650	5.331	5.225	3.033	6.244	5.514	IMO A.749(18)
Fresh Water (s)	98%	9.772	9.576	9.772	9.576	0.275	-8.10	7.229	IMO A.749(18)
Fresh water (p)	98%	16.857	16.519	16.857	16.519	0.268	7.497	7.049	IMO A.749(18)
Bilge water	98%	18.684	18.310	20.464	20.055	17.039	0.000	1.147	IMO A.749(18)
B.W.T 1(S)	98%	5.416	5.307	5.283	5.178	6.803	-7.65	5.618	IMO A.749(18)
B.W.T 1(P)	98%	5.416	5.307	5.283	5.178	6.803	7.648	5.618	IMO A.749(18)
B.W.T 2(S)	98%	83.599	81.927	81.560	79.928	39.936	-7.36	2.682	IMO A.749(18)
B.W.T 2 (P)	98%	83.599	81.927	81.560	79.928	39.936	7.358	2.682	IMO A.749(18)
B.W.T 3 (S)	98%	88.163	86.400	86.013	84.293	61.023	-7.46	1.826	IMO A.749(18)
B.W.T 3(P)	98%	88.163	86.400	86.013	84.293	61.023	7.464	1.826	IMO A.749(18)
B.W.T 4 (S)	98%	38.913	38.135	37.964	37.205	85.572	-8.53	3.687	IMO A.749(18)
B.W.T 4(P)	98%	38.913	38.135	37.964	37.205	85.572	8.529	3.687	IMO A.749(18)
B.W.T 5 (S)	98%	10.642	10.429	10.383	10.175	102.25	-5.67	4.348	IMO A.749(18)
B.W.T 5 (P)	98%	10.642	10.429	10.383	10.175	102.25	5.673	4.348	IMO A.749(18)
SUMP TANK	98%	15.000	14.700	15.000	14.700	9.500	-1.00	6.735	IMO A.749(18)
Total Load case			14609.7	1471.68	1442.25	61.815	0.010	4.120	
VCG fluid								4.120	

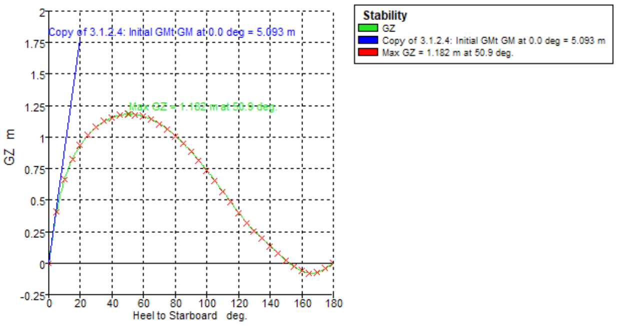


Figure 9: GZ Curve at full load arrival.

parallel to that of GZ is drawn from 'K' and N is the point of intersection of this line with the vertical line of action of buoyancy [15].

The value of KN can be calculated as follows,

Righting Lever (GZ) = KN- KG × sinθ

KN = GZ + KG × sinθ

2.5.1. KN Calculation using Maxsurf package

Maxsurf computer software was used to generate plots of KN curve using various heel angle degrees, draft (m) and displacement tons.

Table 4: Full load Arrival conditions

Item Name	Quan-tity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	4923.0	4923.0			60.80	0.000	3.525	0.000	User Specified
Cargo	1	8000.0	8000.0			68.00	0.000	4.500	0.000	User Specified
Main Diesel Engine	1	100.00	100.00			25.00	0.000	2.000	0.000	User Specified
Generators	3	50.000	150.00			15.00	0.000	2.000	0.000	User Specified
Crane 1	1	50.000	50.000			45.00	0.000	7.000	0.000	User Specified
Crane 2	1	50.000	50.000			90.00	0.000	7.000	0.000	User Specified
H.F.O (S)	20%	235.83	47.166	280.75	56.15	28.42	-6.310	3.236	61.59	IMO A.749(18)
H/F.O (P)	20%	235.83	47.166	280.75	56.15	28.42	6.310	3.236	61.59	IMO A.749(18)
HFO Daily Service	20%	31.655	6.331	37.685	7.537	27.72	3.717	2.461	1.122	IMO A.749(18)
Fuel Oil (s)	20%	113.07	22.615	119.74	23.95	26.02	-3.144	2.614	10.87	IMO A.749(18)
Fuel Oil (p)	20%	113.07	22.615	119.74	23.95	26.02	3.144	2.614	10.87	IMO A.749(18)
Fuel Daily Service	20%	98.207	19.641	104.00	20.80	25.00	0.000	2.320	6.295	IMO A.749(18)
Lube Oil (s)	20%	6.353	1.271	6.906	1.381	17.75	-3.738	3.372	6.002	IMO A.749(18)
Lube Oil (p)	20%	6.353	1.271	6.906	1.381	17.75	3.738	3.372	6.002	IMO A.749(18)
Hydraulic Oil (s)	20%	4.745	0.949	5.331	1.066	3.083	-5.658	5.035	2.643	IMO A.749(18)
Hydraulic Oil (p)	20%	4.745	0.949	5.331	1.066	3.083	5.658	5.035	2.643	IMO A.749(18)
Fresh Water (s)	20%	9.772	1.954	9.772	1.954	0.331	-7.802	6.218	0.873	IMO A.749(18)
Fresh water (p)	20%	16.857	3.371	16.857	3.371	0.315	7.075	5.911	2.776	IMO A.749(18)
Bilge water	20%	18.684	3.737	20.464	4.093	16.95	0.000	0.873	20.76	IMO A.749(18)
B.W.T 1(S)	20%	5.416	1.083	5.283	1.057	7.242	-7.364	5.232	0.963	IMO A.749(18)
B.W.T 1(P)	20%	5.416	1.083	5.283	1.057	7.242	7.364	5.232	0.963	IMO A.749(18)
B.W.T 2(S)	20%	83.599	16.720	81.560	16.31	41.18	-6.965	1.527	15.09	IMO A.749(18)
B.W.T 2 (P)	20%	83.599	16.720	81.560	16.31	41.18	6.965	1.527	15.09	IMO A.749(18)
B.W.T 3 (S)	20%	88.163	17.633	86.013	17.20	61.08	-7.128	0.847	29.05	IMO A.749(18)
B.W.T 3(P)	20%	88.163	17.633	86.013	17.20	61.08	7.128	0.847	29.05	IMO A.749(18)
B.W.T 4 (S)	20%	38.913	7.783	37.964	7.593	83.20	-8.417	2.345	0.909	IMO A.749(18)
B.W.T 4(P)	20%	38.913	7.783	37.964	7.593	83.20	8.417	2.345	0.909	IMO A.749(18)
B.W.T 5 (S)	20%	10.642	2.128	10.383	2.077	101.4	-5.404	3.584	1.146	IMO A.749(18)
B.W.T 5 (P)	20%	10.642	2.128	10.383	2.077	101.4	5.404	3.584	1.146	IMO A.749(18)
SUMP TANK	80%	12.000	9.600	12.000	9.600	9.500	-1.000	6.600	2.385	IMO A.749(18)
Total Load case			13552.	1468.6	300.9	63.82	0.002	4.080	290.7	
FS correction								0.021		
VCG fluid								4.102		

Following inputs were used for initial draft of 4.5 m and final draft of 9.5 m conditions. The range of vessel displacements starts from 4924 tons to 14924 tons and the vessel were tested under the heel angles from 0° to 180° at intervals of 10°. The resultant curves are collectively called the KN Cross Curves of stability and were obtained as shown in **Figure 11**.

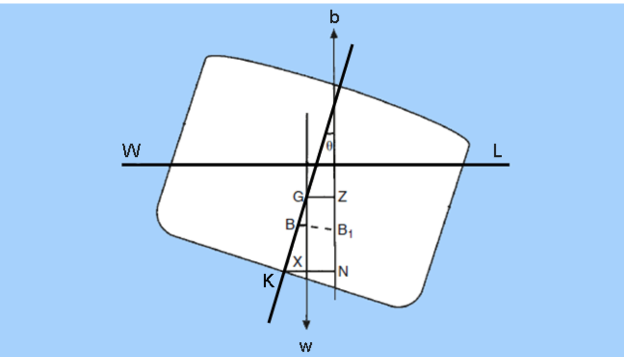


Figure 10: KN stability

2.6. Limiting KG value Calculation

The limiting values from KG calculation and curves are basic requirements during design process since they are used as part of a MPCV stability analysis for a designed vessel [1].

The calculation was based on the concept of metacentric height (GM). This is the difference between the height of the vessel centre of gravity and metacentre (from keel), (KM) height above base to metacentre and the KG (KG = KM – GM). KM varies with draught, trim and heel, whereas

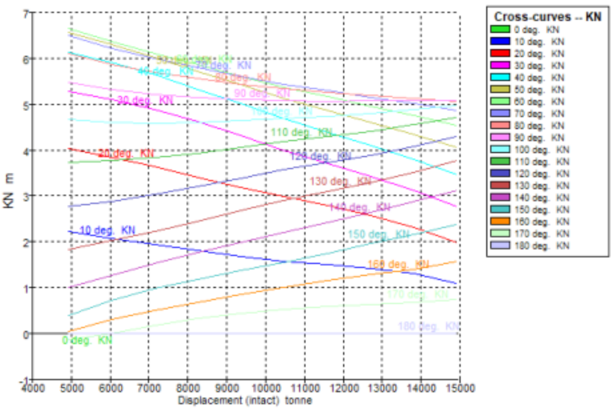


Figure 11: KN curve

KG is a fixed point based on the distribution of weight and so is independent of draught, trim and heel [1].

In this Limiting KG analysis, we take a look at two loading conditions: fully loaded departure condition and fully loaded arrival condition using Maxsurf tool [10].

2.6.1. Limiting KG at Fully load departure condition

Heel to port; heel range: from 0° to 180° in steps of 5°.

Stability Criteria tested: IMO, A A.749 (18) Code on Intact Stability Chapter 3.1.2.1-4, Design criteria applicable to all ship, Using Maxsurf package, the obtained results of **Table 5** were used to plot the graph shown in **Figure 12**.

3.0. RESULTS DISCUSSION

3.1 Vessel Stability GZ curve for fully loaded departure condition

The result obtained from curve of full loads departure condition on **Table 3** and **Figure 8** demonstrate that the maximum righting lever (GZ_{MAX}) was 0.963 m when the vessel heel is at an angle of 70.9° degrees. This angle

Table 5: Limiting KG value result at departure condition

Displacement (intact) Ton	Draft Amidships m	LCG m	VCG m	Limit KG m	min. GM m
4924	4.196	57.120	7.647	7.647	6.008
5977	4.678	56.839	7.764	7.764	4.666
7555	5.381	56.800	7.691	7.691	3.514
8608	5.848	57.081	7.463	7.463	3.200
9661	6.337	57.823	7.070	7.070	2.391
10713	6.857	58.980	6.526	6.526	2.441
11766	7.394	60.285	5.904	5.904	2.757
12819	7.946	61.669	5.460	5.460	3.019
13871	8.564	62.866	5.183	5.183	2.358
14398	9.017	63.029	5.078	5.078	1.812
14924	9.586	63.098	5.020	5.020	1.511

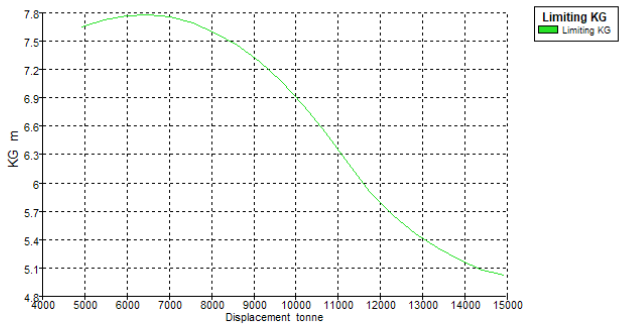


Figure 12: Limiting KG curve

implies a large static heeling moment that is required to bring the ship back to its upright position [9].

Beyond this heel angle of 70.9°, the righting lever or the stability of the ship decreases drastically. The point where the GZ curve meets the horizontal axis is called the point of vanishing stability which is 178°, righting lever now becomes zero at this point. So, any heel beyond this angle would result in a condition of negative stability [15]. The distance between the origin and point of vanishing stability is called the range of stability. For the designed MPCV, it vanishing stability angle are between 0° to 178°.

3.2. Vessel Stability GZ curve for fully loaded arrival condition

The arrival condition **Table 4**, GZ curve **Figure 9**. The maximum righting lever (GZ_{MAX}) is 1.182 m at heel angle of 50.9°. Beyond this angle of 50.9°, the righting lever or the stability of the ship decreases drastically. The point where the GZ curve meets the horizontal axis indicates the point of vanishing stability of MPCV, which is 150° less 28° from the full loaded departure condition. So, any heel beyond this angle would result in a condition of negative stability. The distance between the origin and point of vanishing stability is called the range of stability of a ship which range from 0° to 150°.

The total area under the curves notifies on how stability of the vessel is. The smaller area under the curve imply lower vessel stability and large area under the curves implies to large vessel stability [15]. This implies that the departure conditions of the MPCV are more stable as compared to the arrival condition.

3.3. Cross Curves of Stability

The KN curve result enables us to predetermine the vessel stability curve at any vessel loading, as well as new loading conditions. The result recorded from the KN curves **Figure 11,** indicate that at vessel displacement of 4923 tons and 10-degree angle of heel, it gives KN value of 4.034m, then at 10-degree angle of heel. But for vessel displacement of 14924, the KN value is 1.987. The second selected angle of heel was 80 degrees, the vessel displacement at 4924 tons, KN value was 2.369 m and at 14924 tons displacement, the KN value decrease to 0.048 m.

The increase of the heel angle and ship displacement leads to the decease of the KN value, which may cause to loss of stability. The MPCV was tested under the IMO-Stability Criteria, A A.749 (18) Code on Intact Stability Chapter 3.1.2.1-4, Design criteria applicable to all ship and pass [13].

3.4. Result of Limiting KG value for both conditions

The result of Limiting KG is expressed on **Table 5** and **Figure 12**. It is identified to have equal result but on the different loading conditions. Both have maximum limiting KG value of 7.691 M at displacement of 7555 tons and minimum limiting KG value of 5.020 m at 14924 tons displacement.

Therefore, the limiting KG is independent from any loading conditions. Minimum GM value were 1.51m at 14924 tons displacement, which implies that the ship complies with the IMO stability criteria and the Multipurpose Cargo Vessel design is feasible and it is safe to proceed to the next design process.

4. CONCLUSION

The effective study of ship's design parameters functions on intact and damaged conditions analysis will help to produce better allocation and arrangement plans for machinery, cargo hold, equipment (crane), wheel house and stowage and will ensure sufficient stability for satisfying the IMO-SOLAS criteria [13].

Stability properties are certainly dependent on the main dimensions and shape of the vessel. To meet the specific criteria for damage stability in the initial stages of vessel design, KG is a very important measure of the vessel's ability to withstand severe damage during service [11]. The designer should be aware on the relationship between this measure KG and the ship's dimensions.

During the vessel stability analysis, we have seen that maximum righting lever (GZmax) when multiplied with the displacement of the ship, gives us the value of the maximum heeling moment that the ship can sustain without capsising. These are used in case the ship is operating in a loading condition that it has not operated on before; the GZ curve can still be obtained easily and the vessel's stability determined [11].

The limiting KG is used at loaded displacement to establish whether the loaded condition is safe. The area under the curve is a safe load condition. The area above the curve is an unsafe load condition.

Finally, the ship design and stability subject need a continuous and extensive research aiming at enhancing safety.

Acknowledgment

I would like to express my deep and sincere gratitude to Prof. V. V. S. Prasad, Head of the Department, Marine Engineering, Andhra University, Visakhapatnam with whose guidance, vision and motivation this article was made possible.

Nomenclature

KG	The distance between Keel and Centre of gravity
GZ	Distance between the centre of gravity and the point Z which the line cut to Metacentre
KN	Distance between the centre of the Keel and point N of the line curve cut to metacentre
IMO	International Maritime Organization IRCLASS Indian Registrar Classification Society
GM	Distance between centre of gravity and Metacentric height
MPCV	Multi-purpose Cargo Vessel
TEU	Twenty feet Equivalent Unit

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References

1. Chelladurai S.K.P, Nagarajan.V & Sha. O.P (2020): Study on the lightship characteristics of merchant ships. *71*(3), 37-70, https://dx/doi.org/10.21278/brod71304
2. Damen (2016): Multipurpose cargo vessels, *Brochure*. (https://products.damen.com/en/clusters/multi-purpose-vessel-shipping)
3. Hofman, M & Bačkalov, I (2008): Ship database for preliminary design. *Technical report* BR01/2008, University of Belgrade.
4. Kalajdžiću, M & Momčilović, N. (2019): On Preliminary Design of Multi-Purpose Cargo Vessels. 352-361. https://www.researchgate.net/publication/336589050.
5. Kalajdžić, M & Momčilović, N: A step toward the preliminary design of seagoing multi-purpose cargo vessels. *71*(2), 75-90. http://dx.doi.org/10.21278/brod7120.
6. Klanac.A (2011): *Design method for safe ship structures*. Alto University publication series. http://lib.tkk.fi/Diss/Design-method-for-safe-ship-structures.
7. Lamb, T., (Eds) (2003): *Ship Design and Construction*. The Society of Naval Architects and Marine Engineers.
8. Lin C. K., & Shaw H. J. (2016): Preliminary parametric estimation of steel weight for new ships. *Journal of Marine Science and Technology, Springer Japan, 21*, 227 –239, https://doi.org/10.1007/s00773-015-0345-y.
9. Luhmann, H. & Pöttgen, J. (2015) Design for Safety and Stability. *Proceedings of the 12th International Conference on the Stability of Ships and Ocean Vehicles.* 1, 17-22
10. Maxsurf program manual (2014): Naval Architects program. *Formation design system Pty.* https://maxsurf.net/maxsurf-manual-2014.
11. Papanikolaou.A (2014): *Ship design: Methodologies of preliminary design.* Springer; https://doi.org/10.1007/978-94-017-8751-2.
12. Rule and Regulations for the construction and classification of steel ships (2016): India Register of Shipping: https://www.irclass.org/main_rules_Julay_2016.
13. Ship design and stability: IMO, https://www.imo.org/en/ourwork/safety/page/shipdesignandstabiliy.
14. Schneekluth, H., Bertram, V (1998): *Ship design for efficiency and economy.* 2nd ed., Butterworth-Heinemann, Oxford.
15. Wardhana, E.M & Soetardjo, M (2018): Stability prediction of a multi-purpose vessel. *Journal of Ocean, Mechanical and Aerospace, 61*(1) 1-5.

TECHNICAL NOTES

LUBE MATTERS 5
FOURIER TRANSFORM INFRARED - SPECTROSCOPY (FTIR)

Infrared spectroscopy is a widely used technique for the analysis of fresh & used lubricating oils

Sanjiv Wazir

Introduction

FTIR testing and analysis identifies characteristics of organic chemical compounds and bonds and is used in a very wide range of industries including lube oil analysis.

Principle

Electromagnetic waves include X-rays, visible light, infra-red, microwaves, and radio waves. These waves all travel at the speed of light but differ in the wavelength and frequencies. The whole range of electromagnetic waves is known as the electromagnetic spectrum.

Infrared radiation

Infrared radiation is part of the electromagnetic spectrum and covers electromagnetic waves with wavelengths between 0.00008 cm and 0.04 cm. Scientists have adopted a more convenient method of describing infrared radiation in terms of the number of waves that occur per centimetre. This number is called the WAVENUMBER (= 1/Wavelength). Infrared analysis only uses a portion of the IR spectrum known as "Mid-range infrared". It is defined as infrared waves having wavenumbers between 4000 cm^{-1} and 400 cm^{-1}.

The chemical bonds within organic molecules are in a state of continual vibration, with bonds stretching and contracting as well as bending relative to one another. When an infrared beam falls on a molecule, waves of specific frequencies (wavenumbers) are absorbed from the beam by the molecule, and result in changes to the molecular vibrations of the molecule. The actual frequencies of the waves absorbed depends on the types of bonds present in the molecule's structure. Different types of bonds within the same molecule would absorb different frequency bands while several identical bonds would all absorb the same frequency bands and give rise to stronger absorptions (See **Figure 1**).

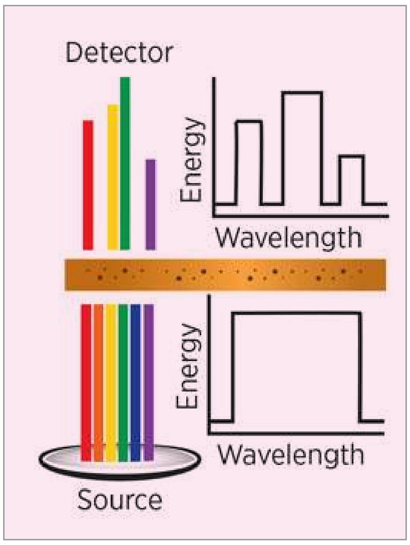

Figure 1: IR Principle [1]

An INFRARED SPECTROMETER can scan frequencies in an infrared beam and measure the strength of frequencies after the beam has passed through the sample in a sample cell. The response of the chemical to specific regions in the infrared spectrum is examined and weighted, each being unique to the characteristic being analysed. The absorbance values are calculated for output in an infrared spectrum. The output of spectra from a spectrometer is generally in the form of a plot of Absorbance vs. Wavenumber as it is directly proportional to the concentration of the absorbing compound.

Infrared spectroscopy is a widely used technique for the analysis of fresh & used lubricating oils. Testing relies on observing how much Infrared radiation the lubricant absorbs as a function of the frequency of that radiation. **Figure 2** shows such spectra for a lubricant.

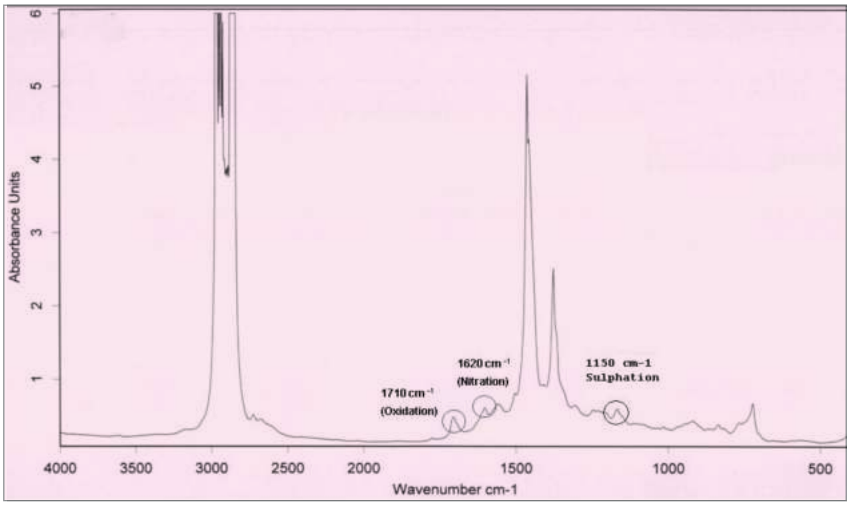

Figure 2: IR Spectra of a lubricant indicating some wavenumbers of interest [2]

Infrared radiation is part of the electromagnetic spectrum and covers electromagnetic waves with wavelengths between 0.00008 cm and 0.04 cm

Analysis

Used oil samples are complex mixtures of many different chemical compounds and include compounds derived from the original formulation of base oil and its additives, oil degradation products and oil contaminants. A used oil spectrum is the sum of the spectra of all the individual compounds and bonds making up the sample. The spectrum of a used oil sample alone is of limited value. It must be compared against the spectrum of the unused oil to enable understand how the usage has impacted the oil .

Figure 3 shows transmittance spectra from two oil samples that are superimposed on a common grid. The upper spectrum is that of a new oil and middle spectrum is that of the same oil, after a period of usage in a diesel engine. Apart from the displacement of transmittance values, caused by the presence of soot in the used oil sample, there appears to be little difference between the two samples, and it might appear that minimal degradation has occurred.

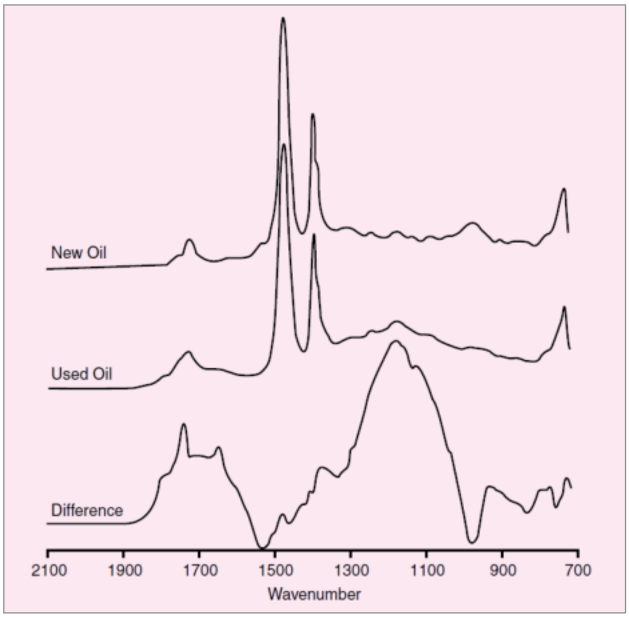

Figure 3: New Oil, Used Oil & difference spectra [3]

However, when the difference spectrum is viewed the picture is quite different. A Difference (or Differential) Spectrum is obtained by subtracting the absorbance spectrum of one sample form that of the other (the y-axis for the difference spectrum has been magnified for clarity in **Figure 3**). This process is carried out by the spectrometer's internal microprocessor. Data for each sample is collected and converted into a numerical format which is subsequently subtracted from that of the new oil, to yield the difference data.

The detailed study of these spectral data enables the analyst to determine the level of changes that have taken place in the used oil, vis-à-vis the new oil.

In UOA FTIR may be used for measuring levels of Oxidation, Nitration, Sulphation, Soot (reported in Abs/0.1mm), Fuel ingress, Water & Glycol (reported as % wt.).

References:

1. Benefits of FTIR Oil Analysis, Machinery Lubrication, Noria Corp, 08/2015
2. Used Engine Oil analysis – User Interpretation Guide, CIMAC No.30, 2011
3. FT-IR Analysis of Used Lubricating Oils – Thermo-Fisher Application Note 50731
4. Tribology & Lubrication (TLT) magazine, STLE (various issues)

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GUIDELINES ON SAFETY DURING ABANDON SHIP DRILLS USING LIFEBOATS

REF: North Club's website;
IMO: MSC.1/Circ.1578, 19 June 2017

Introduction

It is essential that seafarers are familiar with the life-saving appliances on board their ships and that they have confidence that the appliances provided for their safety will work and will be effective in an emergency. Frequent periodic shipboard drills are necessary to achieve this.

Crew training is an important component of drills.

It is a supplement to initial shore-based training, on board drills and training will familiarise crew members with the ships' appliances and the associated procedures.

The objective of drill and training is to develop appropriate crew competencies, enabling effective and safe utilisation of the equipment required by the 1974 SOLAS Convention, as amended (SOLAS).

Drill Frequency

Experience has shown that holding frequent drills makes the crew more familiar with the life-saving appliances on board their ships and increases their confidence that the appliances will work and will be effective in an emergency.

Drills give the opportunity to gain experience in the use of the safety equipment in cooperation.

The ability to cope with an emergency and handle the situation is improved by frequent drills.

However, frequent crew changes sometimes make it difficult to ensure that all on board has the opportunity to participate in drills when the minimum required drills are conducted only.

Therefore, consideration needs to be given to scheduling drills as necessary to ensure all on board have an early opportunity to become familiar with the ship appliances and systems.

Drills must be safe

Abandon ship drills should be planned, organised and performed in accordance with relevant shipboard requirements of occupational safety and health so that the recognised risks are minimised.

Drills provide an opportunity to verify that the life-saving appliances are working and that all associated equipment is in place, in good working order and ready for use.

Before conducting drills, it should be checked that the lifeboat and its equipment have been maintained in accordance with the ship's maintenance manuals and any associated technical documentation, as well as noting all the precautionary measures necessary.

Abnormal conditions of wear and tear or corrosion should be reported to the responsible officer immediately.

Emphasis on Learning

Drills should be conducted with an emphasis on learning and be viewed as a learning experience, not just as a task to meet a regulatory requirement to conduct drills.

Whether they are emergency drills required by SOLAS or additional special drills conducted to enhance the competence of the crew members , they should be carried out at safe speed.During drills, care should be taken to ensure that persons on board familiarize themselves with their duties and with the equipment. If necessary, pauses should be made during the drills to explain especially difficult elements.The experience of the crew is an important factor in determining how fast a drill or certain drill elements should be carried out.

Abandon Ship Drills

Abandon ship drills are an important aspect to ensure safety on board, even in times of crisis. While these drills are commonly taking place along with other drills, such as fire drills, knowing how to properly act when an abandon ship situation occurs can really save lives.

For this reason, John Southam, Loss Prevention Executive, North P&I Club, shares vital information on how to ensure a safe and efficient abandon ship drill.

Often an abandon ship drill is treated as an afterthought to another drill. For example, the main focus will be on the fire drill that precedes it, and afterwards the crew members simply muster donning a lifejacket and then finish.

But knowing what to do and when to do it in the event of an abandon ship situation is a matter of life and death.

So why should it not be a full and properly formatted drill of its own?

Just as importantly, accidents during lifeboat drills – mostly involving hook on-lead release systems when lowering or recovering the lifeboat – continue to occur.

As with the other drill articles in this series, we give you the 'drill bits' – the different elements of the drill. This is to make sure that the crews are familiar with and confident in their actions during a given drill.

Preparation

Complete a full risk assessment prior to the drill – DRILLS MUST BE SAFE!!

This should include assessing whether the weather, environmental conditions, and situation allow for safe lowering, operation and recovery of the lifeboat(s) by the crew.

Use appropriate fall prevention devices and ensure crew are confident in their use. Check operational status and all maintenance is up to date for the relevant emergency equipment.

Split the crew into three small teams and conduct separate training sessions, each led by a responsible officer.

Each team should rotate to the next leader once they have completed each training station, so all crew receive the same training to help in carrying out their emergency duties and responsibilities.

1. Bridge Team

- Location: Bridge
- Group leader: Master

Learning Objectives:

- Demonstrate use of GMDSS: remember this equipment isn't just bridge radio equipment!
- Show the team where to locate the search and rescue transponders (SART) and how they work
- Using the test function, show the team the concentric circles on the 3cm radar (if there are no other vessels in the area)
- Show the team the Emergency Position Indicating Radio Beacon (EPIRB), explain how it floats free and how to manually remove it from its position.
- Demonstrate the location and use of the GMDSS handheld radios, point out to the team where the spare batteries are.
- Explain the content of the contingency plans relating to abandon ship and where they can be found. Check all relevant situations are addressed in the plans and that the contents are accurate.
- Understand record-keeping. Describe how training records should be maintained, remembering that these may prove to be valuable evidence in the event of an incident.

2. Life raft Team

- Location: At one of the life raft muster points
- Group Leader: 3rd Mate

Learning Objectives:

- Discuss the importance of mustering promptly. The type of vessel and the nature of the incident that leads to an abandon ship situation can have a great bearing on how little time the crew might have in an emergency.
- Run through everyone's responsibilities: remind the team that they have individual responsibilities that they must know how to complete themselves in the event of an abandon ship situation. This may include collecting GMDSS equipment or additional water and food – ensure everyone knows where these are stored.
- Show the team the location of nearest lifejackets and immersions suits – everyone should don an immersion suit and lifejacket to make sure they can do this quickly and correctly.
- Explain to the team how the hydrostatic release unit (HRU) works on the rafts and how to check it is attached correctly.
- Explain the manual launching sequence of the rafts. Show the team how to locate the instructions, reminding them that the SOLAS manual in the mess room is an additional valuable source of information.
- If the raft launching arrangements are davit-type, or the vessel has a marine evacuation system (MES), spend time on how they work and their use.
- Ask the crew on what equipment they will find in the raft when it is inflated. Ensure they know how to use the pyrotechnics and when they should be used.

3. Lifeboat Team

- Location: At one of the lifeboat muster points
- Group Leader: Chief Officer

Learning Objectives:

- Run through individual responsibilities in the event of an abandon ship according to the muster list, stressing the importance of understanding their duties. This should include knowing the location of equipment that need to be gathered prior to mustering.
- Show the team where the nearest lifejackets and immersion suits are.
- With all fall prevention measures in place, the team should board the boat, donning lifejackets. They should locate a seat, then be asked to put on their seat harness. This can demonstrate how difficult this can be.
- Demonstrate how to operate the cabin lights.
- If fitted, explain how the oxygen and sprinkler systems work.
- Show the team where to locate the lifeboat loose equipment. Explain how it works and what it is for, including the pyrotechnics.
- Show them the emergency steering, how to set it up and its operation.
- Explain how to start the engine, let them try to start it. If possible (and the cooling system allows it), run the engine ahead and astern.
- Explain how the lifeboat lowering mechanism works and where to locate the instructions, reminding the team that the SOLAS manual in the mess-room is an additional valuable source of information.

All parties

- Location: At one of the lifeboat muster points
- Group Leader: Chief Officer

Learning Objectives:

- Muster all the teams together at a safe distance from the lifeboat.
- Describe the launching and recovery process – referencing company standing orders.
- Explain why incidents have happened in the past that has led to serious injuries and fatalities.
- Testing of the launching arrangements will depend on the type of system on board your vessel.
- For lifeboats lowered by means of falls, inspections and testing of launching arrangements are to be performed in accordance with SOLAS Ch.III Reg.20. For example, operate the winch brake on the vessel, ensuring no crew on board the lifeboat, lower the boat to the point where the auto-releasing gripes become free. Or follow the test requirements for the lifeboat on the vessel.
- For free-fall lifeboats, simulated launching should be carried out in accordance with the manufacturer's instructions.
- Remember to log all tests and lifeboat launchings.

Debriefing

Drills are about learning and not just as a task to satisfy regulatory requirements

Assemble all groups and then each group leader should highlight any lessons learned and encourage questions from the team. Don't forget to highlight what went well and give praise where it's due.

It is extremely important to emphasise that individuals must know and fully understand how to conduct their responsibilities in the event of an abandon ship drill. A common Port State Control deficiency is where it is observed that the crew know what it says on the muster but do not know how to carry out their allocated responsibilities properly. No matter how small your responsibility seems, your role is likely to be essential.

[Original article published in North's website.]

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THE ARCHITECTURAL ODYSSEY OF THE WESTERN COAST OF MUMBAI

Amruta Talawadekar

Mumbai or Bombay as it was previously called, portrays as the city of dreams for anyone who enters the city. From being the financial capital of India to be one of the largest metropolitan cities in the world, this city has been an important landmark for business and livelihood since ancient times. The peninsula of Mumbai has a vast coastline and a geographically deep natural harbour, making it an important landmark for trade and commerce. While the city, originally seven marshy islands, was occupied by a few Koli inhabitants during the earlier times, it saw an evolutionary transformation with the arrival of the British in the 17th century.

The city has seen subsequent alterations and additions to its original form in terms of its population, nature of trade and geography. The city transformed from a broken marshy coastline to an uninterrupted large coastline. While a lot has been written on the coasts of Mumbai, the study has been in parts catering to limited components across few areas of the city. The paper intends to trace the journey of the evolving coastline of the Western shore of Mumbai since the arrival of the Europeans in the mid-16th century and its impacts on the city as well as its environment.

The original habitants along the western coast

Originally an archipelago, the seven islands namely Mahim, Parel, Worli, Mazgaon, Bombay, Old woman's Island and Colaba that eventually formed the city of Mumbai were individually governed by different rulers prior to the 16th century (See **map a**). The original inhabitants were the Agri (salt pan workers), Kunbi (cultivators), Bhandari (toddy tappers) and Koli (involved in fishing, boat building and net drying) communities who majorly settled on the western coast with access to plenty of water and land for their occupational activities. Mahim was governed by Raja Bimb and had Brahmans, Prabhus, Bhandaris and other castes inhabiting the island. It is said that a fort was built at Mahim to watch out for the invaders coming from the Arabian Sea.

An influx of the Muhhamedan era in the 15th century in terms of architecture and community was also seen. The Island of Worli or Varli was a hill having a settlement at the foothills. A great breach between the Worli Island and Bombay Island allowed the sea to lush inside during high tides. The southern islands of Colaba and Old Woman's Island were occupied by the fishermen huts and were divided from the island of Bombay by a wide strait of considerable depth even at high tide. Although no official records were found, a few settlements were said to have existed on the island of Bombay prior to the arrival of the Portuguese. The coastline was broken as the seawater would enter between the landmasses. Some of these islands were accessible by foot during low tide.

The arrival of the Europeans

When the Portuguese arrived in Bombay, they took over all the islands of Bombay from the various rulers and forcefully converted the inhabitants to follow Christianity. Some were called the East Indians who continued practicing occupation that was dependent on the sea like fishing, boat building, agriculture etc. The island of Bombay had an ill fortified house, a garden and a few settlements. The early signs of reclamation of the islands were seen during this time when the Portuguese financer advised the king to offer grants to the locals who fill the submerged land from water.

Nevertheless, since Bassein was the important port for the Portuguese along the western coast of India, they paid little attention to Bombay and its development.

Initiation of the first reclamation

Bombay was given as a dowry to the British Crown who then leased it to the English East India Company. It was the arrival of the English East India Company in Bombay that changed the geographical, commercial and demographical look of the city. The Company rapidly exerted their vision of transforming Bombay into a

Image 1. Mumbai's skyline as seen from Bandra
(Source - https://scroll.in/latest/833803/ mumbai-on-high-alert-after-coast-guard-says-terrorists-trying-to-enter-city-by-sea-report)

modern city based on the British cultural and socio-political elements. The early accounts of Frere, a European traveller indicate that when viewed from the island of Bombay, a mixed population of English, Portuguese, Indo Portuguese and natives stayed on the other islands and practiced fishing. Between the islands were 40,000 acres of good land that was under the water.

The Company, unlike the Portuguese, wanted to enhance trade and commerce in the city. They called out for various merchants, craftsmen and people from various professions to settle in the city and promised tax exemption and religious tolerance. Soon a fort wall was built around the castle of Bombay to protect the town from attacks from the West. Thus, the islands had the main Bombay fort along with small forts and watchtowers on every island. The original inhabitants chose to continue with their occupations and resided on the coast.

The area between the islands began to act as a nuisance and a breeder to diseases after which the then Governor Gerald Aungier sent a plea for reclamation in the 17th century claiming that the breaches were eating up almost one-third of the rich and potential area and that reclamation would benefit trade and security of the city. First attempts to reclamation were done as early as the year 1739 with the Love Grove Dam. The Dam had been planned to stop the water from coming in between Worli and the H shaped island of Bombay (see **map b**). The newly opened land for cultivation near the source of irrigation proved beneficial and a higher population was recorded to have settled thereafter.

Subsequent attempts to reclaim and change in built form

As the population of the islands gradually increased, the water between the islands became a garbage dump and breeding area for diseases. Thus by 1710, the breaches in the north at the Mahim Bay and between Worli and the Island of Bombay were closed, which was followed by the Hornby Vellard reclamation in 1784. The project consisted of building a seawall blocking the Worli creek to prevent the low-lying areas of Bombay from being flooded at high tide and that created more land for reclamation. This resulted in the construction of various causeways connecting the islands, whose end product was the unification of all seven islands by 1845.

Thus, the entire western shore became one large unified stretch from Mahim to Colaba (difference: see **map c**). By the early 19th century, the Fort of Bombay was stuffed with people and new planning initiatives were introduced to decongest the Fort area. The Great Fire of 1803 acted as a trigger to the development of the area beyond the Fort. This led to the demolition of the Fort wall and the opening of the adjacent space to the west of the Fort (Esplanade).

Image 2. The Hornby Vellard reclamation
(Source - https://www.theguardian.com /cities/2016/mar/30/ story-cities-11-reclamation-mumbai-bombay-megacity-population-density-flood-risk)

With the increase in trade and the cotton boom due to the American Civil war in 1861, the need for better infrastructure was realised. The unexpected influx of wealth gave Bombay the capital required for regulating and advancing the reclamation of the foreshore of the island as a strategy to open additional usable land for the rapidly growing town which was steadily metamorphosing into a city. Much of this money was channelled into rebuilding the core of the town into a grand showpiece and portraying the city as a symbol of prosperity. The esplanade was used to build grand government buildings that were elegant and had a large footprint, very different from the buildings within the Fort. The Central India railway was also accommodated on the Esplanade.

The Back Bay reclamation was a new scheme envisaging reclamation, all along the western side of the southern tip of the city with a beautiful promenade that would not only have apartment blocks and office buildings but also public squares. While it was partly completed in the end of the 19th century, the turbulence in the share market and the collapse in reclamation companies led to the part construction of Back Bay. The reclamation was later completed in 1909, opening new areas of Marine Drive, Nariman Point and Cuffe Parade (difference: see **map d**) after which a new phase of Art Deco buildings came up along the west coast of Mumbai. The Art Deco buildings were totally new in design and construction from the Victorian Gothic Style of architecture across the esplanade.

This obviously transformed Bombay's skyline and visually structured its western edge. The inception of reclamation trusts and companies such as the Elphinstone Land Company and Bombay City Improvement Trust largely escalated the reclamations in the city. Thus, the Back Bay reclamation opened up new avenues and vistas with a great view and a good sea breeze. Grand roads along the western shore also made travel more delightful. This marked the emerging era of contemporary urban development in the city unlike the unplanned congested development within the original Fort of Bombay. It added an incredible amount of housing stock to the Island city leading to the increase in the population instead of it growing northwards.

Image 3. The newly constructed Marine Drive Promenade
Source - https://www.theguardian.com /cities/2016/mar/30/story-cities-11-reclamation-mumbai-bombay-megacity-population-density-flood-risk)

Emergence of a planning policy

Recognising the rapid increase in the city's population, the post-independence era underwent a major transformation in terms of its planning approaches and urban design. A Development Plan for the Greater Bombay (comprising of the seven Islands and the Salsette Island on the north) was created by the Maharashtra Regional and Town Planning Act of 1964 which would determine the future form of the city and its coastline.

This introduced the concept of FSI (floor space index) which was the ratio of the combined gross floor area of all the storeys of the building to the total area of the plot within which it was to be built and the land use. This was based on the holding capacity of the particular region and the Nariman Point development was gifted with a massive FSI of 3.5 to 4.5 subsequently leading to the construction of corporate buildings of Air India and Ambassador Hotel.

The Environment Protection Act of 1986 issued regulations for activities along the coastline. As per the notification, 500m from the high tide line is to be considered as a Coastal Regulation Zone. The development plan prepared for the city reserves the coastal area from being developed. With the change in political power, the 1990s saw a relaxation in the FSI along the coastal area leading to skyscrapers being constructed along the coast. Soon Mumbai turned into a megacity that housed more than a million people.

Infrastructural upgradation

The Mumbai city that comprised of the seven Islands was now densely populated with narrow congested roads, cramped buildings and a lack of open space. The Mahim causeway became the only link between the Suburbs and

Image 4. The existing Haji Ali Promenade (2019)
(Source - Destructive futility': 10 reasons why Mumbai's Coastal Road Project should be scrapped by Hussain Indorewala)

Image 5. The proposed Haji Ali Promenade after the construction of the Coastal Road Project
(Source - Destructive futility': 10 reasons why Mumbai's Coastal Road Project should be scrapped by Hussain Indorewala)

Image 6. The ongoing construction of the Coastal Road Project is disrupting the coastline of the city
(Source - https://scroll.in/article/933713/mumbais-koli-fisherfolk-are-relieved-the-courts-have-stalled-the-coastal-road-project)

the City of Mumbai. This north-southwestern corridor became a bottleneck during peak hours with no space for development. The Bandra Worli Sea Link and the Coastal Road along the western shore thus came into picture (difference see map 'e'). The pillars that were erected close to the western shore were in the path of the fishing boats and the fish which used to come near the shore eventually stopped coming, resulting in massive losses to the fishermen in the Worli area.

While the Bandra Worli Sea link saw a minimum amount of landfilling, the proposed Coastal Road Project claims to undertake reclamation of over 90 hectares. The proposal contains the construction of a 30km eight-lane freeway along the Western shore of Mumbai along with a large reclaimed green space. This will lead to a major transformation of the city's western coastline. The existence of the Worli Koliwadas and its people, who were the original inhabitants of the city will be hampered due to its limited access to the coastline for fishing purposes and the loss of various aquatic species.

Effects on the city

Across the years, the coastline has been moving further inside the sea by reclamation and construction, leading to the hampered channel of the flow of the seawater. This seawater has thus come lashing back to the low-lying areas causing a flood. Addition of infrastructural facilities without consultation with locals has proved to be harmful for the residents of the city. Greed for land and modifications in the Coastal Regulation Zone has resulted in haphazard coastal development and loss of public access to the shoreline.

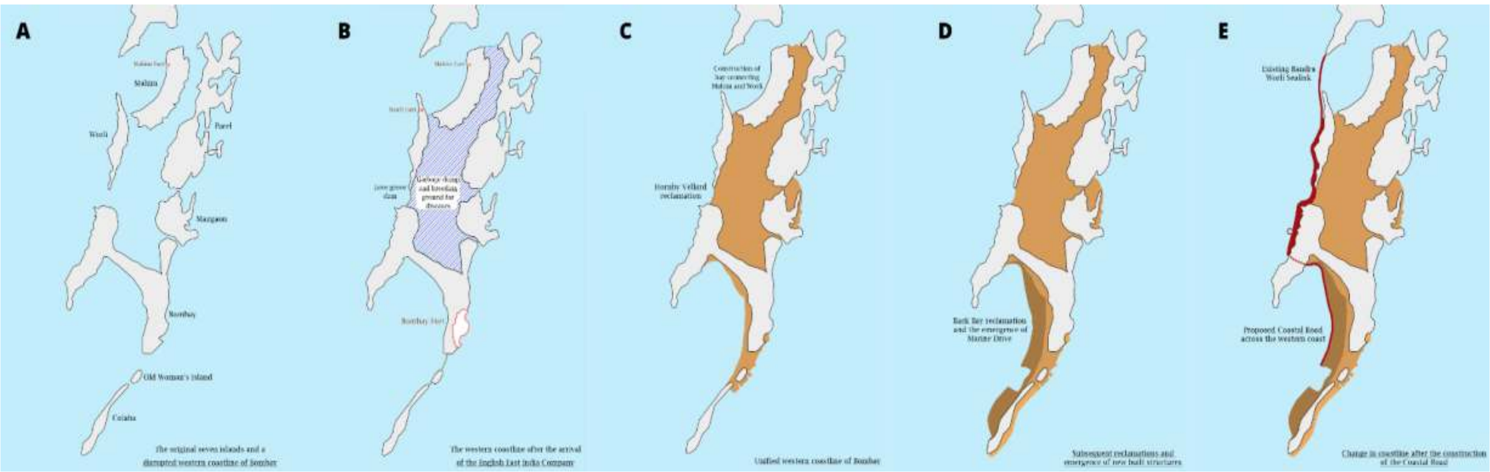
With the rise in population and demand, the pressure on resources is thus increasing, which shall soon lead to an adverse effect on the city. The decision of reclamation on these grounds and the blocking of water by the construction of breaches and causeways to link the original seven islands led to the permanent stoppage of water into the islands. Since the original route of the flow of water was hampered, many of the low-lying areas that were reclaimed fall prey to floods even today.

Mumbai currently lies in the Malabar Coast biogeographical zone which is one of the biodiversity hot spots of Southeast Asia. The Coastal Road Project that boasts to reduce the travel time and thus bring a significant impact on the lifestyle of the citizens of the city will adversely hamper the coastline and its biodiversity.

The suspension of fine sediments in the water column will lose its transparency, which may potentially affect the growth of plants by reducing the availability of light and the photosynthetic process. The rise in PH levels of water may increase, causing an imbalance in the ecosystem. It was also observed that the ongoing reclamation includes dumping of non-oceanic red mud that will suffocate fragile species like crabs and octopuses who have been known to live in burrows of intertidal rocks.

In the fishing waters of Worli Koliwada, large numbers of fish come to the shallow seas for shelter in the rocks and crevices and to breed or lay eggs. The reclamation will destroy the fish breeding ground, substantially affecting the productivity of the entire coastal belt. It will affect the livelihood of the fishing community as they rely on the intertidal species at the rocky shores for fishing.

Image 7. Chunk of garbage being washed back on the coast of Mumbai
(Source - https://www.indiatvnews.com/photos/india-mumbai-rains-high-tide-spills-nearly-361-tonnes-of-garbage-along-marine-drive-see-pictures-452873)



In 2011, the Coastal Regulation Zone (CRZ) norms were revised, allowing increased commercial activity closer to the tidal line, easier reclamation and development of land, higher FSI for nearby buildings, and other such benefits. These relaxed norms are encouraging the BMC to reclaim land for the coastal road. The fisher folks of Mumbai need this coast for their livelihood but because of the new norms and reclamations taking place, land which should be rightfully theirs can be potentially usurped and distributed for development by the state.

The floods of 26 July 2005, that killed hundreds of people was a result of inadequate drainage disturbed by high tide and the city's hunger for space by reclaiming and washing off the mangroves and floodplains. The change in climate and rise in water levels is proof of what the city has been doing for the environment. According to the BMC chief, 80% of Nariman Point will be in the water by 2050.

About the Author

Amruta Talawadekar is an Architect by profession with a postgraduation in Architecture and Urban Conservation from Kamala Raheja Vidyanidhi Institute for Architecture and Environmental Studies. She has been working with the Maritime History Society, Mumbai since July 2019, looking into the research and conservation of the built-heritage lying within the maritime domain. Living in Mumbai, her keen interest lies in the maritime history of Mumbai. Her first research project at the Maritime History Society was based on one of the coastal batteries erected by the British Crown for the defence of the Bombay Harbour, the Oyster Rock Battery. Being a heritage enthusiast and a technical professional, she is inclined towards the shipbuilding practices and techniques of India. She has co-presented a paper on 'Indigenous boatbuilding traditions at Mandvi, Gujarat' with her colleague at the Maritime History Society's Annual Seminar 2019 and anchored a conversation on 'Women in India Maritime History at Maritime History Society's National Maritime Heritage Conclave 2020. She has also presented a paper titled ' Diu- An eyewitness to explorations and annexations' at the Indian Naval Academy's Dilli Sea Power Seminar 2020.

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Conclusion

Thus, the coastline on the western shore of Mumbai has been in a state of continuous evolution since the early 16th century due to various demographical, environmental, occupational and political changes that the city underwent. Occupation based on its coastline, reclamation of land from the sea and changes in the built structure has led to a huge transformation from having an interrupted coastline of the seven islands to a large continuous stretch of the western shore of Mumbai today. As the city progressed in its geographical, demographical and commercial aspects, the transformers of the city did little to cater to its environmental component.

While other countries are learning from their past and building up the future, Mumbai is still looking at the future without considering its past mistakes. The huge chunk of garbage that came flowing back on the western coast of Mumbai is proof of the mistakes done to upgrade the city. As Conservation Architect Mrudula Mane rightly said '*The change is bound to happen. It would be better if we could study how these past changes have impacted us and then try to ascertain what can be the future of these past & present changes*'. Thus, it can be said that the sea around Mumbai may be soothing, but with multiple infrastructure projects forthcoming, its coast is not.

References

1. Arunachalam, B. *Changing geographic environment of Bruhan Mumbai*. Mumbai: Asiatic Society Library, n.d
2. Bhatia, Sidharth. "The Making of Marine Drive." *The Indian Quarterly* (n.d.).
3. Ed by Pauline Rohatgi, Pheroza Godrej , Rahul Mehrotra. *Bombay to Mumbai - A changing perspective.* Mumbai, n.d
4. Edwardes, S.M. *The Rise of Bombay*: A Retrospect. The Times of India Press, 1902.*Gazatteer of Bombay City Vol I*. Mumbai: Government of Bombay, Times Press, 1909
5. Tindall, Gillian. *City of Gold - The Biography of Bombay*. London: Maurice Temple Smith Ltd, 1982
6. Mehrotra, Sharda Dwivedi and Rahul. "Bombay - The Cities Within." n.d
7. Murphy, Noel. "Evolutionary Mumbai: Making of the 'Island City." 2013
8. Riding, Tim. "Making Bombay Island - Land reclamation and geographical conception of Bombay." 2017.
9. Roychowdhury, Adrija. "A city stolen from the sea - The greed that breeds Mumbai's struggle with rain." *Indian Express* (23 July 2018)
10. Vimal Shah, Pankaj Joshi. "Revisioning Mumbai - Conceiving a manifesto for sustainable development." Promilla and Co. for Asiatic Society of Mumbai, n.d

DEVELOPING PERMANENT, SUSTAINABLE APPROACHES TO GOOD SEAFARER MENTAL HEALTH

Ashutosh Choudhary &
Ashutosh Kumar

Introduction

Mental Health includes one's psychological, emotional and social well-being – one's mental state affects what they understand, feel and act. Being a seafarer is no easy job! A 22-to-25-member crew on-board a vessel in middle of an ocean for about 6 to 9 months at a stretch is a tough situation and can lead to various mental health disorders. According to the WHO, about 264 million individuals are tormented by mental state connected problems.

Mental Health & Our Occupation

Seafaring is defined by a novel set of options that sets it aside from other occupations. This includes demanding physical operating conditions, venturous tasks, long hours of labour etc. This can result in high levels of stress and fatigue. Increasing degree of automation aboard ships has resulted in smaller crews and crew members could be from different cultural and ethnic backgrounds. Things that has been outlined various times as a humanitarian crisis by international bodies like IMO, ILO etc., do not clearly relate to these.

Problems Faced by Seafarers

There are numerous factors that possibly can increase the risk. Some main risks are:

- Long working hours on-board can result both physical and mental draining
- Varying experience levels of crew members and related issues
- Stress due to fear of failures (mistakes etc.)
- Stress due to long periods of being away from home
- Financial situation for dependants in the family
- Automation, the complexity of systems and related issues of control, reliability, training, and alarm management, job competency and self-doubts
- The fear of criminalisation
- The pressure of frequent inspections and administrative tasks
- Commercial pressure from ashore
- Communication issues (language etc.) and/or culture
- Multinational crews

Effcets & Consequences

The above-mentioned risks and factors are the major ones. The consequences are highlighted in the figure.

Some of the causes and symptoms are discussed briefly.

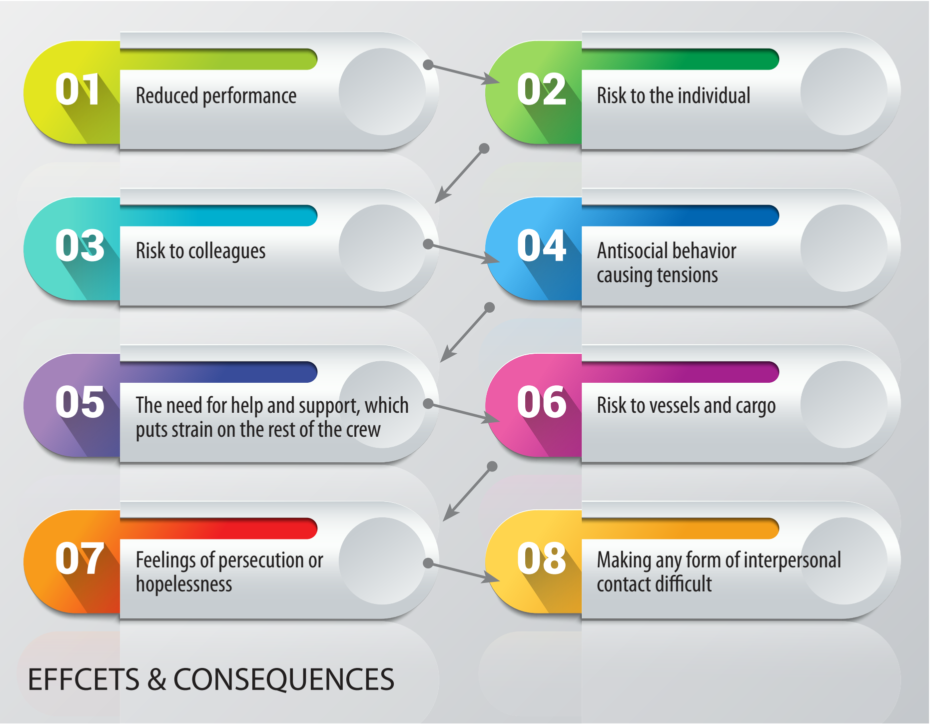
Stress

Job stress can occur when the requirements of the job do not match with the abilities, resources, or the expected needs.

Typical symptoms of job stress are shown.

Six key areas or 'risk factors' that can be causes of work-related stress on board. These are:

- The demand of the job
- The level of control a seafarer has over his/her work
- The support received from management and colleagues
- Relationships at work
- The seafarer's role in the organisation
- Change and how it is managed



Depression

Depression can be considered in two forms. The first has an obvious cause. However, clinical depression overwhelms and engulfs day to day life, interfering with ability to work, study, eat, sleep, and have fun. The seafarer may be emotionally up one day and down the next to the extent of being morose and even sullen.

Symptoms of Depression:

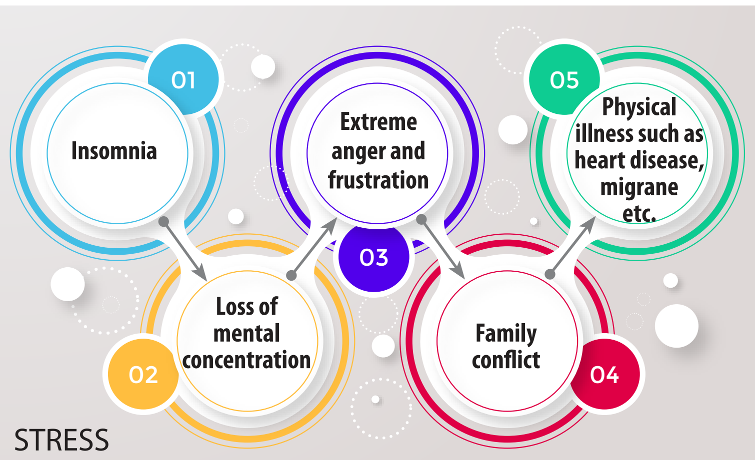
- Depressed moods
- Loss of interest
- Feelings of sadness, little or no emotion
- Changing appetite (eating less/eating more); weight fluctuation
- Sleeping less/sleeping more
- Fatigue (feeling tired) of mind and body; feelings of guilt, helplessness, anxiety, and/or fear, often with little or no reason
- Lowered self-esteem
- Thinking about death or suicide
- Use of drug or alcohol

What are the Solutions?

- To identify the stressors such as work, or family
- To get adequate sleep and rest to maintain energy levels
- To eat a healthy, balanced diet; limited/no intake of caffeine and alcohol
- To develop alternative activities (e.g., hobbies)
- To take support and advice from friends and family
- To consider meditation or gym, aerobics or sports
- To switch focus, and to reorganise priorities

Anxiety

It is normal to worry and feel anxious or scared when under pressure or facing a stressful condition. Anxiety can help an individual to stay alert and focused, act as a spur to action, and motivate him/her to solve problems.



Fatigue

Fatigue can influence performance and certainly when combined with high or low workloads, lead to an accident. Many of the established risk factors for fatigue are present on-board. Fatigue reduces well-being and is a major risk factor for mental health problems such as depression. It also increases the risk of acute illnesses, and life-threatening chronic disease, such as cardiovascular diseases.

Disruptive Thinking and Behaviour

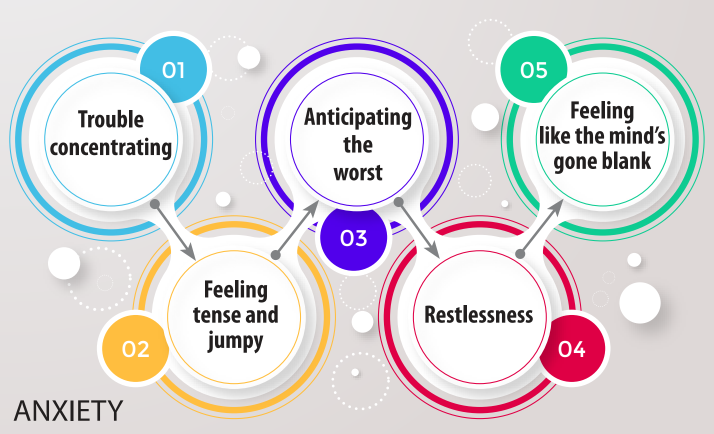
Any seafarer with severe psychotic mental illness will require a great deal of care and attention. In such cases, professional medical advice should be sought urgently. A mentally ill person may experience delusions or hallucinations. It could lead to a **psychotic** state.

Our Proposed Solutions

Onboard Measures

The following measures may be considered during the voyage of a seafarer.

- Encourage and stimulate the crew members



- Captain and officers have to show their commitment towards the fresh joiner
- Should have a company health policy to resolve the problems
- Marketing of the plan with proper budget
- Give seafarers the opportunity to make suggestions on prevention activities
- Link MENTAL CARE with SHIP topics on SAFE TRAVEL
- Provide FIT ONBOARD and other SHIP health initiatives

Interactive sessions should be there amongst the crew. Organise events, quiz, games etc. Special days such as birthdays should be celebrated with all crew members.

Pre-Sea Training

Pre sea training is a crucial part. Below are the points which should be taught to them to stay positive:

- Practicing gratitude
- Taking care of physical health
- Connecting with others
- Developing a sense of meaning and purpose in life
- Meditation and relaxation techniques

Conclusion

We have seen that life on board has been affected by Covid-19, as seafarers have to change their routines and be very conscious on the precautionary measures and the risk of exposure. We are happy to highlight some issues on seafarers' wellness in this article.

(This article was adjudged first in the Navgati 2021 Fest of IMU Chennai Campus. The content has been edited for language and number of words.).

About the Authors

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ADDITIVE MANUFACTURING FOR MARITIME INDUSTRY

Rahul D
Indian Maritime University, Mumbai Port Campus

ABSTRACT Shipbuilding has always been a complex and time consuming process with the amount of delays in manufacturing and testing. Thus, to speed up the process, it is recommended that we bring in Additive Manufacturing (AM) also known as 3D Printing. AM technologies have found an industry in which they can bring great innovations for development. As in other fields, the maritime sector is increasing the use of 3D printing technologies and renewing itself according to different needs. This study presents the marine applications of 3D printers which has a wide range of working field. In addition, the latest technologies, projects and applications of 3D printer technology in the maritime industry is examined.

Keywords: Additive-manufacturing (AM), cost-saving, eco-friendly, ship-repair

I. Introduction

The benefits of AM are not unique to limited number of industries. The potential to lower marginal cost, reduced material usage, save weight and time, and develop highly complex designs are compelling advantages of AM technology across industry sectors. 3D printing, known industrially as Additive Manufacturing (AM) has rapidly revolutionised production processes and products within a great range of industries in the last few years. This is caused by specific added values such as weight reduction, free complexity, localised production and many more which is possible because of the AM process. AM is defined as the 'process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies.', ISO/ ASTM (2015) **(Figure 1)**. Examples of these are drilling, CNC milling, bending, etc. which are common within the maritime construction sector.

AM has many opportunities and challenges that require introduction before using this technology. There is a set of technological challenges for AM that are inherent to the process. AM does not benefit from economies of scale, since the costs per product do not decrease with increasing numbers. This makes it more suited for one-offs or small series than mass production. The material integrity, which has a connection with surface finish and post-processing is also a challenge; since AM uses layers to build up the material, properties vary along the direction perpendicular to the layers. The layers also result in a surface alike stair in this direction. These two effects usually result in the need for post processing in the form of heat treatment and/or machining.

AM will always be a trade-off between speed and accuracy and will always be built up in layers with the resulting effects. However, there is still a lot of research to be done on these subjects to be able to quantify and reduce these challenges. The second set of challenges result from the fact that AM is a relatively new technology and can be (partially) considered temporary.

To rise to these challenges, close collaboration of maritime construction sector, AM machine manufacturers and regulatory bodies is required. Only then can new regulations be made on which new research and cases can be based. Standards can follow from these rules and with standards, training becomes relevant as experience is valid over time. Intellectual property also requires close cooperation between engineering and production as well as new laws for property and liability. On top of that, to enable this collaboration and standardisation, the technological challenges need to be clear, within the previous decade:

- Costs have decreased a hundred times for the most inexpensive 3D printers
- Speed has increased more than a hundred times for the most professional 3D printers
- Revenue on printer hardware has increased ten times We are now entering a decade of commercial 3D print mass production.

3D printers still have some serious limitations but the 3D printer industry is dealing with that. The new technologies will disrupt the present ones. Professional 3D printers will mature from the handmade machines of today to mass production and maybe even 3D printing.

The present 3D technology is only available for production of auxiliary components for ships and

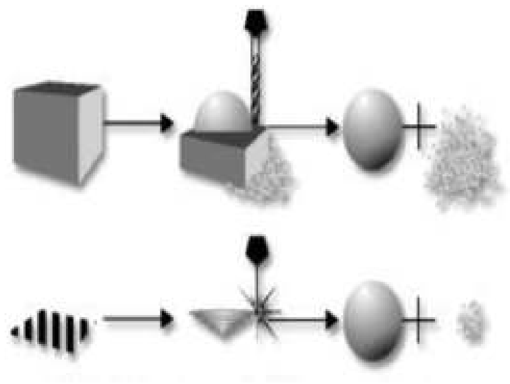
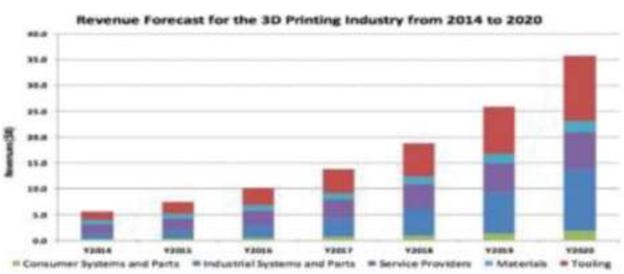


Figure 1: The differences between AM and the traditionally used subtractive manufacturing technologies are schematically shown



particularly components and spare parts for pumps, valves, heat exchangers, engines, propellers and catalysers. 3D print is competitive when the part printed is characterised by:

- High degree of customisation
- Complex design
- High kg price of the component
- Leveraging value due to improved performance
- Urgency of delivery
- Consolidating many components into one

II. Benefits

2.1 Saving Weight and Materials

In case of a propeller the better you get at designing cavities, the more weight and material you save. This is particularly interesting if:

- The material is expensive
- Weight savings enable functionality
- Saving weight saves energy

Look for processes where weight is important. Maybe you can substitute aluminium with a 3D printed hollow steel part. Imagine cavities within the propeller reducing the specific density enough to make it weightless in sea water. In that case, you could switch propellers without dry-docking,

2.2 Single Piece Machinery Parts

You can save a lot of leaks and trouble if your 3D prints one component instead of assembling a device from several components. This is particularly interesting if the device works with hydraulics, water or gasses under high pressure Single piece devices also save assembly and processes justifying the extra cost of 3D print. Heat exchangers and catalysers are good examples of devices which would benefit from 3D printing.

2.3 Complex Geometry

3D print is a tool for complex geometries. You would never choose 3D printing if you want geometries you can extrude – like plates, cylinders, pipes, beams etc. or order from a shop. 3D printing is superior to milling for complex geometries where the volume of the finished component is small compared to the volume to be milled

- Shells
- Lattices
- Mesh and sieves
- Curved, wavy, hilly shapes that are stronger and more efficient than flat smooth surfaces.

2.4 Accurate Cavity Moulds

Moulds reverse the relation between volume kept and volume removed, so 3D printed moulds can often compete with milling. Sand-printing moulds is actually one of the few technologies used for mass production with 3D printers. Addition of multiple moulds could be the way to bridge the gap between the size of 3D printers and the size of ships.

2.5 Just in Time Spare Parts

It is of course easier to 3D print from digital files than from 3D scanning, so we expect to see an enterprise 3D scanning all spare parts to a 3D data base to be used by the 3D printer on board. 3D printing spare parts on board has several advantages:

- No inventory of spare parts on board
- No waiting for vital spare parts delaying the ship.

2.6 Instant Repairs

Spray 3D printers can add material on the surface of existing components. This way existing components can:

- Be repaired
- Have new harder and more wear resistant surfaces
- Have surfaces and coatings otherwise impossible to manufacture. Spray printers are expected on the market this year. A spray 3D printer can be a valuable tool in the workshop on board.

2.7 Faster Product Development

BMW, Audi and Airbus use 3D printing as a way to speed up the development process. The entire prototype car can be made from 3D printed parts. It is much faster than producing handmade prototypes and the parts are much more like "the real thing". Late-ordered or delayed parts from subcontractors can be 3D printed to meet deadlines. These prototype 3D prints can later be substituted by mass produced traditional components.

III. Current Scenario

Maritime industry is characterised by heavy utilisation of equipment and machinery and by really specific operating conditions. Ships work in a very unique operational context, and that makes the requirements of reliability and safety particularly critical (Nenni & Schiraldi, 2013). The type and quantity of the spare parts that must be on board a ship is imposed by the authorities for its safety, or suggested by the original equipment manufacturer (OEM) in order to avoid unexpected breakdowns and ship downtime, or even by experience.

Spare parts inventory is necessary, but it costs (mainly in capital, and in some cases in available space). Various optimisation techniques are used. Nenni & Schiraldi, (2013) propose an approach to calculate the optimum level of inventory for spare parts of ship equipment. Eruguz, Tan, & van Houtum, (2015) consider an integrated maintenance and spare part optimisation problem for a single critical component of a moving asset for which the degradation level is observable.

We conducted interviews (semi structured) with people working in the maritime industry, in order to get an understanding of the supply chain of the spare parts of the ships, and get an idea of how this can be changed with the introduction of additive manufacturing. The need for a replacement may occur either because the predetermined stock has fallen below the threshold, or before a predetermined maintenance or because of an extraordinary damage. If the replacement is not in stock at the ship, then a request is sent to the land office (usually by the chief engineer).

In the land office, after approval from the technical department, the request passes it to the procurement department. The purchasing process is pretty much typical (Purchase Order, Request Quotations, Receive Quotations, Select the supplier, Order, Receive order, Invoice). In this simplified diagram **(Figure 3)**, one must note that the ship is away from the base and changes location. The spare must be timely delivered at the next port that the ship will reach. There is also an option to purchase an imitation of the spare part, or order it at a local workshop. If the requested spare part is out of stock in the chosen supplier's inventory, that must be requested from the regional warehouse, the peripheral warehouse, or finally at the OEM. If it is out of stock at the OEM, then it will be manufactured (as soon as there is economic batch). The spare part made by the AM is comparable with the part made by the traditional method as much stronger and long lasting. Only concern was the cost of the AM machine, and the cost to build the part.

IV. Conclusion

3D print is a competitive alternative to traditional production methods when the product or part is characterised a high degree of customisation and low production volumes. In order to benefit from the distinct advantages that 3D print allows for, such as complex structures or lightweight, the object requires re-thinking and re-design. This requires specific competences and an in depth understanding of 3D print.

Although 3D print technology is constrained by size limitations at the moment and the maritime industry per definition deals with large objects, there is no reason to believe that the technology is irrelevant. We do, however, need to explore the current limitations. By applying a collaborative approach and engage with print technology providers and experts, the maritime industry can take part in the technological development, to their benefit. The technology is still in its infancy, but the pace of development, suggests that we need to engage now, if we are to succeed. Danish stakeholders have, traditionally, been on the forefront of global maritime development. It is only natural that we continue to curiously explore new technologies and usage, to predict the specific impact of 3D printing in maritime applications. That in itself is a reason to continue the exploration. 3D print is one increasingly.

[This paper was included in the proceedings of the National e-Conference on Energy, Environment and Sustainable Shipping, organised by IMU Chennai campus & IME(I) in December 2020]

References:

[1] R Babine, F Karsten, J. P., & R. J. I. Basten, The Impact of Additive Manufacturing on Service Supply Chains. Retrieved from, 2015 http://alexandria.tue.nl/extra2/afstversl/tm/Abbink_2015.pdf

[2] ASTMAM_Standards_Development_Plan_v2.docx(n.d.). Retrievedfrom,2013 http://www.astm.org/COMMIT/AM_Standars_Develop ment_Plan_v2.docx

[3] J.D. Strickland, Applications of Additive Manufacturing in the Marine Industry, Proceedings of PRADS2016, Copenhagen, 2016

[4] T. Wohlers, Wohlers' report 2014: 3D Printing and Additive Manufacturing State of the Industry, Wohlers Associates, 2014

[5] T. Wohlers, "Tracking Global Growth in Industrial-Scale Additive Manufacturing", 3D Printing and Additive Manufacturing, vol. 1, no. 1, pp. 2-3, 2014. Available: 10.1089/3dp.2013.0004.

[6] Y. Zhai, Early Cost Estimation for Additive Manufacture, PhD Thesis, Cranfield University, 2012

[7] https://ww2.eagle.org/en.html (American Bureau of Shipping)

[8] https://www.startus-insights.com/innovators-guide/4-top-additive-manufacturing-solutions-impacting-the-shipbuilding-industry/

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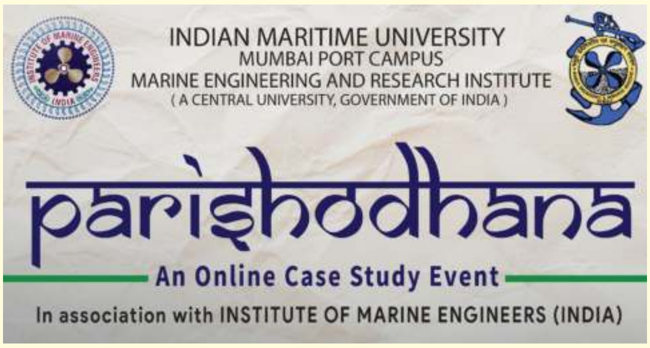
MUMBAI BRANCH

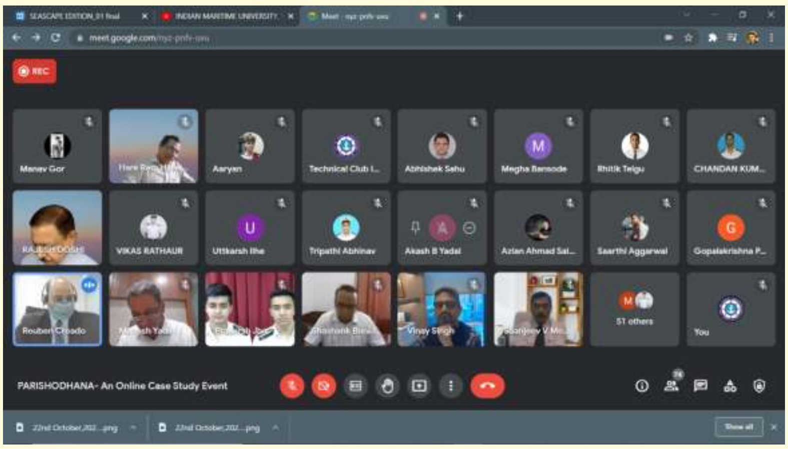
CASE STUDY COMPETITION EVENT AT IMU, MUMBAI PORT CAMPUS

IMU, Mumbai Port Campus in association with The Institute of Marine Engineers (India) Mumbai branch conducted a Case Study Event 'PARISHODHANA' for the cadets of the Campus through online mode on 22nd October, 2021. The case studies focused on problem statements relevant to the current issues of interest to the industry, which included:

- Record backlogs of container shipping leading to congestions in the trans-pacific route
- Indian shipping industry is developing at a rapid rate but still lags as a shipbuilding nation
- Future energy efficiency regulatory rules provide fresh impetus to the shipping industry

The event started at 1400 hours in the presence of the Chief Guest and Judge Capt. Reuben Creado, Deputy General Manager, Andromeda Shipping India Pvt. Ltd and was graced by Mr. Rajesh Doshi, IMEI who also acted as another Judge for the event. Other attendees included Shri. Arun K Gupta, Chairman, Shri. Sanjeev Mehra, Secretary, IMEI Mumbai branch, Capt. M.C. Yadav and other senior Mariners as well as officers and students of IMU Campuses across India. All the dignitaries were welcomed by the Campus Director, Capt. Sunil Chand Panigrahy and Mr. Hare Ram Hare, HOD (Marine Engineering).





The papers were assessed by Mr. Hare Ram Hare, assisted by faculty of IMU MPC. From a total of 13 entries received, 6 were selected for final presentation at the event. The research work and presentation of each team was expressive and gave insights into the issues and highlighted ideas to tackle the various challenges. Each presentation was followed by a Q&A session with the judges. After the commendable presentations, the participants of the event were enlightened by the Chief Guest Capt. Reuben Creado and Mr. Rajesh Doshi. The judges provided guidance and gave suggestions to the cadets for improving the presentations. While the results were being finalised, the guests went through a virtual tour of the campus through a video prepared by the cadets of the campus. Post the video, it was the time for the launch of the first edition of newsletter 'SEASCAPE' compiled by Indian Maritime University, Mumbai Port Campus.

After all the debate, discussion and enlightenment, the judges came up with the results, which according to them was a real close call, as follows:

First Prize: Presentation on 'Record backlogs of container shipping leading to congestions in the trans-pacific route', by Cdt. Ashutosh Choudhary, Cdt. Ashutosh Kumar and Cdt. Abhinav Tripathi.

Second Prize: Presentation on 'Indian shipping industry is developing at a rapid rate but still lags as a shipbuilding nation', prepared by Cdt. Anuj Singh, Cdt. Akash B. Yadal and Cdt. Sourav Patra.

Third prize: Presentation on 'Indian shipping industry is developing at a rapid rate but still lags as a shipbuilding nation' by Cdt. Subhadeep Sahoo, Cdt. Vikas Rathaur and Cdt. M. Manoj Kumar. (Case study with same topic as for Second prize).

A Consolation prize was also awarded to the presentation on 'Future energy efficiency regulatory rules provide fresh impetus to the shipping industry' by Cdt. Anuj Kumar Chouhan, Cdt. Manish Kumar & Cdt. Rahul Singh.

There were appreciations all around. The Chief Guest, Capt. Reuben Creado was presented with a memento as a token of gratitude, and the event concluded with a Vote of Thanks by Shri. Gopalkrishna.

VISAKHAPATNAM BRANCH

VIZAG BRANCH PRESENTS THE EMINENT ENGINEER AWARD

This year the Eminent Engineer Award was given to Mr. P. S. Murthy on 22nd October 2021. Mr. Murthy was elected as Eminent Engineer for the year 2020-2021 during the AGM held on 27th August 2021. The branch congratulated him for his great achievements.

GOA BRANCH

GOA BRANCH GOES GREEN

IME(I) Goa Branch has initiated installation of ROOF TOP SOLAR POWER SYSTEM to take care of the power needs of the IME(I) Guest house. Apart from the advantages of Change over to Green Energy it is expected that considerable savings in the energy / electricity bills would be achieved. The work the work has commenced now, expected to be completed 3 months.

This is festive season, and IME(I) Goa guest house offers decent facilities for its members to enjoy holidays in Goa at very reasonable rates.

Please contact us at imehousegoa@gmail.com. Special discounts are available for members / corporates for extended stays for 30 days and above.

90TH GOVERNING COUNCIL MEETING – AN OVERVIEW

The **90th GC Meeting** of the Institute was held on **10th October 2021** through virtual meeting application Zoom.

The President, Mr. V. K. Jain, chaired the meeting and welcomed the newly elected GC members.

The Honorary General Secretary, Cmde. Bhupesh Tater ran through the Agenda of the GC Meeting which included discussions on adoption of the 89th GCM minutes, Changes in the Trustees in BES, Nominations for various external bodies, change of signatories at HO, and selection of Chairman of Benevolence fund.

The Chairpersons of the various new Subcommittees were finalized and the chairpersons proceeded to list the proposed objectives of their sub-committees and briefly touched upon their plans for achieving these goals.

It was discussed that the Chairmen of each Branch would reach out to the Membership in their region to try and nominate Members from their Branch for each Sub-Committee at HO to ensure seamless implementation and workflow across branches.

The lack of nominations and office bearers at the Pune and Delhi Branch and the Patna Chapter was noted and discussed. Efforts would be made to prevent such a situation in the next term.

The Proposal to amend the ORP for co-opting of Members into sub-committees was discussed.

The GC was updated about the status of various other issues including digitalisation redevelopment of IME(I) Website, Digitalisation of IME (I) Publications, status of opening of the Singapore Chapter, redo of the i-Connect App amongst others.

The meeting ended with a vote of thanks to the Chair by the Vice President, Mr. Amit Bhatnagar.

IN THE WAKE

Rajoo Balaji

Corona Chronicles

The Maritime Safety Committee (MSC), approved the draft IMO Assembly resolution. Full approval expected: December 2021.

Highlights:

- seafarers as "key workers" (safe movement across borders for shore leave; exempt from proof of vaccination etc.)
- implementation of the Industry recommended for safe ship crew changes and travel
- vaccination of seafarers, (prioritise in respective national vaccination programmes)
- immediate access to medical care/evacuation (especially when required medical care is not possible on board/in port of call).

Another significant approval: Guidance on seafarers' training and certification.

This should be interesting since it will contain recommended practices, force majeure situations, all aligning with STCW Convention.

Meanwhile a note of Covid-19 caution: Beware of a new contagious mutant in circulation (Newsroom buzz: The militant-mutant has already entered India).

Shipping Matters

We are back to a prehistoric period: pandemic; inactivity; ships wait in ports for berthing; logistics delays; goods are taking longer to reach… Freight cost of 1 TEU had stayed below US$2000 but now like a hissing cobra's head is pushing past US$10000.

The supply chain has now many weak links slowing down everything connected. Absence of goods has caused manufacturing to slow down. Inflation inching up?

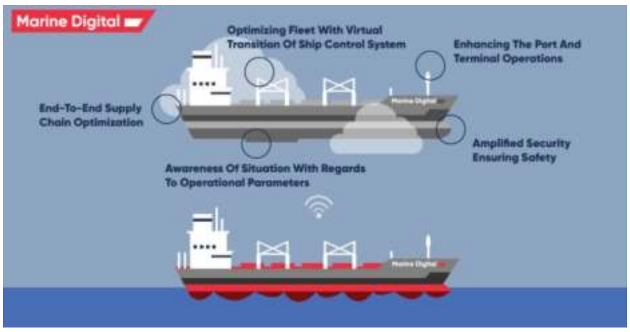
Are we adapting? Yes, trying to. Trains, trucks airplanes… are being used. But warehouses are full and so are the ports. An interesting letter in The Economist from Guy Platten (SG, ICS) makes couple of noteworthy observations: Governments have forced workers (read seafarers) to remain on ships during the pandemic (for > 1 year); refused transit across borders. Hence, workers are leaving the industry. He emphasises that if workers' woes are not prioritised/addressed, supply chain issues will get worse. Any parallel thoughts?

Tech Talks:

More on the digital twins (DT) which is getting attention from maritime sector (continuing from my last inputs):

DT was first conceived by NASA. Now DT moves from space to sea.

Areas which can benefit: Fleet management (technical etc.); optimisation of ship operation and thereby the supply chain; cyber security. A snapshot to whet your interest:



Source: Marine Digital; Sealuminati

About November

The month has days for infants and children…

7th, 14th, 16th: Infant Protection Day; Children's Day (National), Universal.

Amongst others, one which drew the attention was the World Television Day (21st).

Guess in the present times, every day is a TV Day.

THE END VIEW

Idea, Words & Drawing: **Ramesh Subramanian**

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