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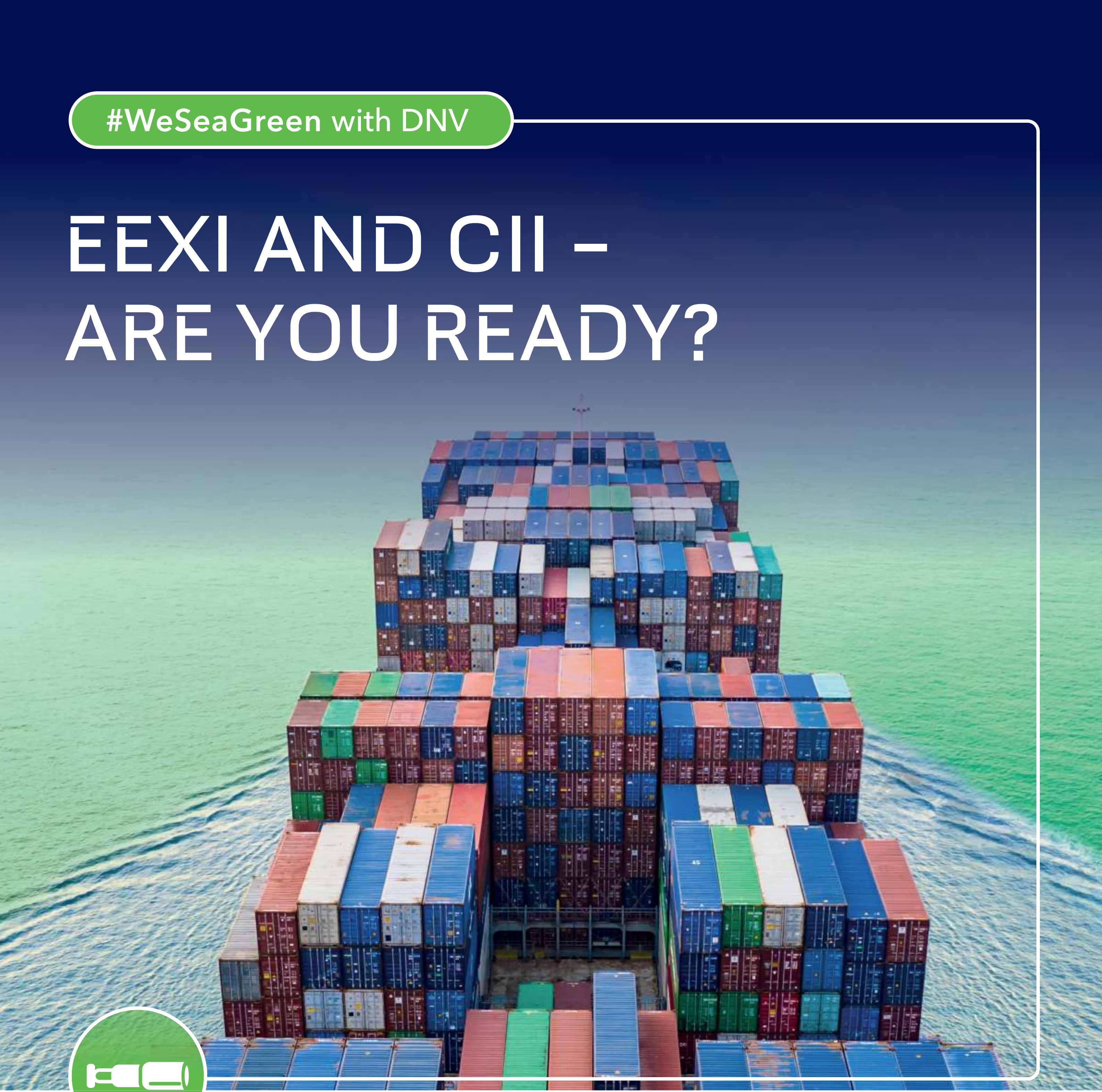
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EDITORIAL

Faster, Higher, Stronger, Together...
–Motto of the Olympic Games

7 and 3.63Kgs: Number and the weight of the medals we collected at the Tokyo Olympic Games.

We wish these numbers had gone into double digits. A quadrennial wait it shall be and we will certainly better these figures. As I pen this, we climbed into double figures in the on-going Paralympics. That is heart-warming... Let us hope for more.

Another statistic where we are just breaching the double figures is of a greater concern...

We have done the double dose for just over 10% of the total population. The battle still rages against the Delta+ variants, the sceptics and those scared to take the jabs. If we have to hang the signboards, 'Life as usual - New Normal', we must ensure a protection which the science offers as of now. And vaccination appears to be the only rational choice. As industries power up and schools are dusting the benches for the students' arrival, the vaccination drive has to be faster to have a higher number of protected population (if possible the planned target) by the year end. And together we must work for a stronger immunity barrier.

In this issue...

Blue and green may be declared as the colours for the decade that is rolling on. The blue seas are going to be fishing grounds for development. Dr. Purnima Jalihal takes the topic and makes a good case as to why India must look at the oceans. Surfing down a historical wave, Dr. Jalihal swiftly checks the current comparative status of ship building, offshore, ports etc., urging that the nation must recognise market opportunities for job creation and frame policies aligned with such ideas. Focus on shipbuilding and tapping ocean resources are a couple of takeaways, while Dr. Jalihal enlightens us with the works being done by NIOT in the oceans.

Next, we continue dwelling in the ocean depths with Part B of the AUV series. In this second part, Dr. Vedachalam and Dr. Ramadass discuss the hardware maturity using reliability checks, mission capabilities based on path-optimising algorithms and the demands for increasing spatiotemporal capabilities. The scientific approaches are brought out with the underlying principles in a simple manner, taking care of the readers' comprehension also.

Following the seas, we have Dr. Jai Acharya's essay on the environmental shipping and climate change. Climate change requires a holistic approach and maritime transport will be both an affected and affecting party. Relying on various reports, Dr. Acharya highlights many efforts and lists several ongoing projects. One may tie up the recent efforts towards mitigating emissions etc., to make the long summary comprehensive and to sight relevance in the present contexts.

We have a surge of feedbacks on the MET Thematic issue and we feature a clutch of three write-ups under Indicator Cards. To observe one, Dr. Surendar Kumar's penning peeping into the past with a foot in the future of assessments/training makes a quick and interesting read.

In the Competency Corner, we have Chief Engineer Narayana Prakash discussing the significance and on board operational issues of 'as-built' drawings. This should draw the attention of practicing marine engineers.

Post this September edition... we hope to put our Journal Management System into use.

And I hope you will get to flip through the flipbook versions soon...

We look forward to your reflections.

Dr Rajoo Balaji
Honorary Editor
editormer@imare.in

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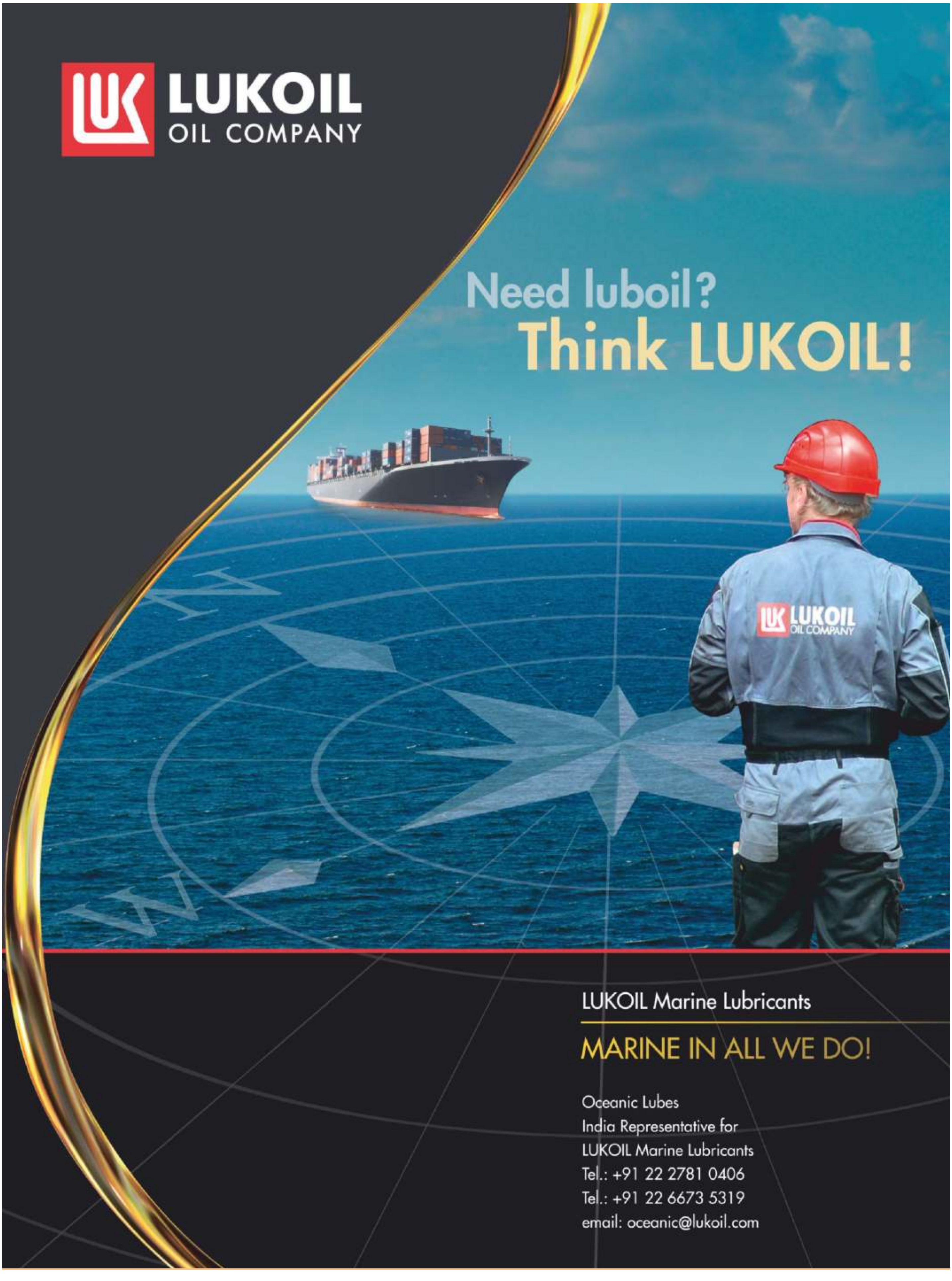
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OCEAN TECHNOLOGY – WHY IS IT IMPORTANT FOR INDIA?

Dr. Purnima Jalihal
National Institute of Ocean Technology

1.0 Introduction

The word Maritime immediately conjures images of ships. Historically, maritime was associated with exploration and conquests of new lands and shores. Christopher Columbus was an Italian explorer and navigator who completed four voyages across the Atlantic Ocean, opening the way for the widespread European exploration and colonisation of the Americas. His expeditions, sponsored by the Catholic Monarchs of Spain, were the first European contact with the Caribbean, Central America, and South America [1]. In 1492, when Christopher Columbus sailed westward from Spain, he thought he was headed to East Asia. Columbus did not realise he had landed at a new land mass or continent and that Europe, Asia and Africa were not the only continents. While the European shipping adventures were largely for exploration and to gain more lands, the facet of discovery was inbuilt in the cruises. Thus Maritime had always conjured up images of new discoveries, places, people and other scientific data while parallelly charting courses, mapping coasts and continents and thus sailing added to the knowledge base worldwide.

The conquest of knowledge and conquest of territory became mingled especially in the 18th and 19th centuries. On July 1, 1798, Napoleon landed in Egypt with 400 ships and 54,000 men and proceeded to invade the country, as he had recently invaded Italy. But in addition to soldiers and sailors, Napoleon brought along 150 savants — scientists, engineers and scholars whose responsibility was to capture, not Egyptian soil, but Egyptian culture and history. And while the military invasion was an ultimate failure, the scholarly one was successful beyond anyone's expectations [2]. They founded an entirely new discipline called Egyptology and made important contributions to religion, linguistics and botany. Later in 1831, Britain's Royal Navy sent a ship to map the coasts of South America because the knowledge would help them to keep their grip there. But along with the mission of exploration, they added a geologist Charles Darwin to the crew. While the mapping was being carried out, Darwin parallelly worked and collected data, which finally culminated in the Theory of Evolution.

What is the maritime scene in India? A notable archaeological discovery is the presence of an ancient dock at Lothal dating back to 700-1700 BC. In the 14th and 15th centuries Indian ship building was quite advanced with sizes large enough to house a large number of sailors with compartments as safety measures to retain buoyancy in case of leaks in voyage [3]. However with the advent of invaders like the Portuguese, Indian naval power declined with the Portuguese taking control of the Bombay harbour. There was a short revival during the seventeenth century when Shivaji began to consolidate his own fleet and kept invaders at bay. However after the passing of his trusted commanders, the naval power declined rapidly.

India is a peninsula with a long coastline, which made it vulnerable to attacks by many countries using maritime routes for trade. Maritime in general includes explorations, ships, ship building, fishing, trade, sea mapping, offshore, etc.

Moving slightly from the historical perspective to definitions of some terms, let us understand what marine engineering is. This is a branch of engineering which deals with design, building, installing and operating marine craft, docks and ports and machineries thereof. However, Maritime Engineering is loosely used more in the offshore context for the offshore installations especially in the oil and gas industry. Lastly, today a broader canvas is ocean engineering and includes knowledge of oceanography, coastal engineering, offshore engineering, resources, exploration, marine biology, shallow waters as well as deep waters and many more. All these areas are big fields on their own and the following sections discuss the Indian position on these and the way ahead. There is a need to look at the Indian situation today in this context and beyond.

2.0 Current Indian Status

Let us first look at the maritime industry i.e. from the ship and ship building perspective.

2.1 Shipbuilding:

We have just a little over 20 shipyards. Many major ports are now able to handle container carrying vessels and port infrastructure is progressing. However, we have the capability to build small ships with drafts only less than around 3m. We have practically no offshore handling equipment like large capacity crane barges, anchor handling barges or powerful tugs.

There are very few shipyards which can handle large and deep drafted vessels. Export of built vessels from India is presently better than consumed by the domestic market. The state of ship building in India is shown in **Table 1**, which captures discussions from [4] and gives the position of Indian shipbuilding as compared with China.

Experts feel that China has an edge even over the US in shipbuilding, and it could give the country an advantage in a protracted conflict in which both sides may see heavy losses at sea [5].

"China has already achieved parity with—or even exceeded—the United States in several military modernisation areas," the Pentagon reported recently, identifying shipbuilding as one area where China has an advantage.

	China	India
Ship building and repair yards	492	28
Manufacture of equipment	148	Nominal
No. of employees (total industry)	2,87,702	60,000
Order Book	40m DWT	1.3m DWT
Global Share	19-20%	1%
Steel Availability	High	Low
Minimal Labour cost (US $/hr., approx.)	1.19	0.28

Table 1 Comparison between China and India in the ship building industry

"The People's Republic of China has the largest navy in the world, with an overall battle force of approximately 350 ships and submarines including over 130 major surface combatants," the Pentagon assessed in its latest China Military Power report. The Pentagon also reported that "China is the top ship-producing nation in the world by tonnage," adding that the country is currently striving to increase "its shipbuilding capacity and capability for all naval classes." Among the surface combatants China is building are cruisers, destroyers, and corvettes and the country is also continuing to build support ships, amphibious warfare vessels, and aircraft carriers for expeditionary operations and power projection [5].

> *However, when coastal protection measures are taken up, there is still a tendency to rely on expert consultants from abroad*

This clearly shows how much we are lagging in ship building and from the future strategic perspectives, Indian shipbuilding needs drastic upscaling.

2.2 Ports and harbours:

What is our status compared to other countries?

Traffic at major ports reached 704.82 million tonnes in FY20. India has 12 major and 205 notified minor and intermediate ports. Under the National Perspective Plan for Sagarmala, six new mega ports will be developed in the country [6]. The Indian ports and shipping industry play a vital role in sustaining growth in the country's trade and commerce. India is the sixteenth-largest maritime country in the world with a coastline of about 7,517 kms and a very large EEZ due to the Lakshadweep group and Andaman and Nicobar group of islands in the Arabian Sea and Bay of Bengal respectively.

The Indian Government plays an important role in supporting the ports sector. It has allowed Foreign Direct Investment (FDI) of up to 100% under the automatic route for port and harbour construction and maintenance projects. It has also facilitated a 10-year tax holiday to enterprises that develop, maintain and operate ports, inland waterways and inland ports [7]. Many port and harbour related works are being taken up within the country but built by companies from abroad. When it comes to building a full-fledged breakwater we still have a huge dependency on foreign companies. Similarly, where coastal engineering is concerned, **IITs and some research institutes like NIOT do have experience in coastal process modelling and wave hydrodynamics etc**. However, when coastal protection measures are taken up, there is still a tendency to rely on expert consultants from abroad.

2.3 Offshore Construction and Installation:

As far as offshore construction is concerned, we have a handful of companies involved in offshore design and installations. Some big companies have a presence abroad

and are also carrying out jobs for ONGC. The smaller ones are mainly into backend jobs for offshore markets. We are yet to build a deep water tension leg platform or a semi-submersible in India.

The other area of concern is the offshore handling equipment and infrastructure. Large crane barges, anchor handling and pipe laying barges and high capacity tugs are low in number and totally insufficient for large deep water installations. Many times, vessels have to be hired from Singapore, Malaysia and other countries which are very expensive in the mobilisation and demobilisation costs along with daily rates. Class certified offshore installation vessels if available, more jobs can be taken up indigenously which is lacking today.

3.0 The need of the hour:

What should the future be like? For economic upscaling we need to consider the following aspects:

1. **Jobs creation:** Indian shipping industry is fairly labour intensive. Construction activities need lower level semi-skilled and skilled workers in large numbers, hence undertaking large projects in the sector will create lower level jobs. However as is discussed later, there is a need for technical expertise as well as management required to take indigenous projects from concept to commissioning. Thus the possibilities of jobs requiring different levels of expertise are very obvious.
2. **Market opportunities:** Assuming we work on activities which lead to job creation, this is fine for internal economic wellbeing, but which activities need to be taken up? There has to be a proper assessment of market opportunities. The better the opportunity, the more profitable the investment and internal wealth creation can happen automatically. However, in the current situation with low infrastructure available, catering to realistic market opportunities will be difficult. This necessitates infrastructural investment as discussed later in this article.
3. **Policy framework:** In the West, policy frameworks are put in place for any new ventures and then funding is taken up. Apart from the Sagarmala program, which is the first large scale program envisaged for the ship building industry, there is still a large need for policies for offshore and ocean technology. While a couple of Ministries/ Departments are working on related activities, a focussed expansion program in the ocean technology area is yet to be started.

   The Ministry of Earth Sciences has now embarked on the Deep Ocean Mission, which has some aspects like technology development, oceanographic surveys and measurements, marine biological studies and infrastructure. However, this is more of a R&D exercise and while capacity building will definitely be a fallout, many significant issues in offshore and ocean technologies will be touched only superficially. Thus policies are required to be made for the issues which are discussed below.

How do we decide where the investment should be?

How do we achieve self-reliance and growth at the same time?

To address these issues, let us divide the marine sector and ocean technology into the following components:

3.1 Trade, commerce, shipping infrastructure

a) **Ports, breakwater and harbours:**

This sector is under the purview of the Sagarmala program and there are several opportunities for the growth of the sector and hence this article will not dwell on it.

b) **Ship building from design to construction – shipyards including deep drafted vessels:**

For existing shipyards to become even more impactful, they should be able to handle deep drafted vessels increasing the spread of their activities to varying vessel types. This again needs engineers trained in analysis and design of vessels as well as infrastructure and large investments to create the facilities for construction and dry docking. These activities have the potential to create a huge number of jobs both skilled and unskilled.

c) **Offshore fixed and floating platforms :**

India should also take up building of fixed and floating platforms for oil and gas as well as other specialised potential markets. Currently all ONGC platforms are built by foreign companies. The BLE platform is a case in point (see **Figure 1**). Today ONGC has signed agreements with IITs for innovative methods for maintenance and safety and other issues during operations. While this is a good initiative, it remains to be seen whether academia alone can get the desired

India should also take up building of fixed and floating platforms for oil and gas as well as other specialised potential markets

Figure 1 ONGC B193, Offshore Mumbai
(Courtesy brucedale.net Dec 2013)

It appears therefore that it may be easier to design small devices (wave and tidal energy harnessing) for extreme conditions in the Indian seas

results. There is a huge knowledge gap in design, fabrication, installation and commissioning of these platforms.

Floating platforms like semi-submersibles have not been built in India and we need to embark on such construction. Semi submersibles have an important role to play in the context of offshore desalination and energy especially using the temperature gradient in the sea. Such platforms could be envisaged as combined / hybrid platforms for water, energy, aquaculture and other such applications. While these may seem futuristic, it is important to take steps towards this to strengthen our offshore capabilities.

3.2 Resources

The oceans are a huge repository of resources and no road map is available for harnessing these. Apart from the potential of benefit to coastal populations, the offshore expertise developed for harnessing these resources can directly help the offshore capability and indigenisation. Let us look at the various resources.

a) **Renewable energies** – ocean energy, offshore wind, floating solar PV and desalination

Ocean energy is the need of the hour for coastal regions and remote locations and islands. Wave energy, marine currents and tidal streams and ocean thermal gradient based energy are under study currently in the country. It is known that wave energy density as also currents are lower than those in northern latitudes. This has led to the understanding that it may not be viable to harness wave energy in India. However, what is seldom understood is that, in the northern latitudes though the potential is very high, large prototypes have failed in severe cyclonic conditions due to which though the devices are successful, their safety is still under question.

Some of the wave energy and tidal power devices around the world are shown in **Figures 2 & 3** respectively.

In India, the small devices demonstrated offshore have withstood cyclone conditions during the monsoons and performed well. It appears therefore that it may be easier to design small devices (wave and tidal energy harnessing) for extreme conditions in the Indian seas. The floating wave powered navigational buoy and hydrokinetic turbine developed by NIOT are shown in **Figures 4 and 5**

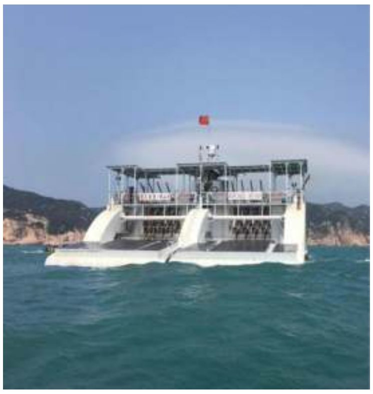

Figure 2a: China Sharp Eagle

Figure 2b: Sweden Corpower

Figure 2c: USA Columbia Power technologies

Figure 3a: Canada Cape Sharp Tidal

Figure 3b: Italy GEM Device - The Ocean's Kite

Figure 3c: China LHD Xiushan

respectively [8]. The quantum of energy harnessed per meter is less than Europe for instance, but the device can be designed to be safe. Thus the issue to address is not the technical viability as much as the commercial viability which can only be understood by demonstrating large capacity prototypes offshore through Government funding.

India has a huge coastline with several coastal areas having paucity of power and water and new technologies need to be demonstrated for successful scaling up and commercialisation. Ocean Thermal Energy Conversion (OTEC) is a base-load power generated using the thermal gradient in the ocean. The surface sea temperatures are warm throughout the year ranging from around 27 °C to 31 °C in the peak summer. The waters at around 1000m water depth generally are between 7-8.5 °C. This difference can be used to generate power using OTEC. The temperature gradient can also be used to generate fresh water which has been demonstrated by the NIOT at several islands of Lakshadweep in the Arabian Sea.

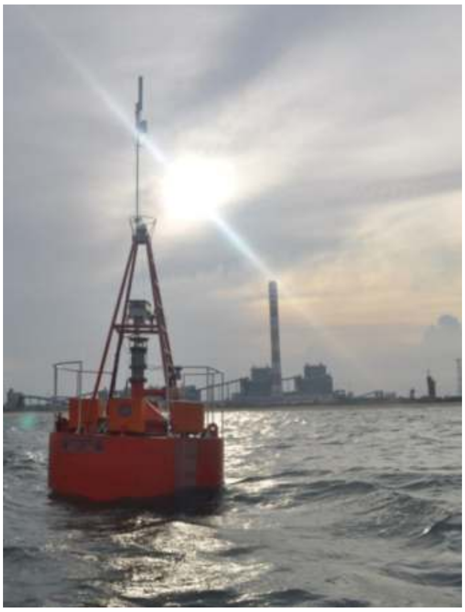

Figure 4 Wave powered navigational buoy

These plants have become very successful and are also environmentally safe unlike membrane methods which result in brine formation as well as there is a need to replace the components like membranes at regular intervals. OTEC is capital intensive, however for such technologies we need to talk about economies of scale and with higher capacities, we can get lower costs.

Indian offshore industry needs to be seriously improved and to this end, prototype demonstration projects are also important for the learning curve. Offshore floating platform for OTEC in deep waters involves the platform, moorings and the complex cold water conduit to draw water continuously from deep waters. The challenges for doing this are many and can lead to huge capacity building for people at all levels – engineers, analysts, designers, ship yards, installation contractors and handling mechanisms onshore and offshore. Today world over, offshore wind is being studied and some implementations have taken place across the world. This also needs to be attempted in India for understanding the techno commercial viability. Floating solar PV has been attempted in many countries and many are on rivers and backwaters. The real challenge is to have floating solar platforms in the open sea. The biggest drawback of solar PV is the large footprint required on land. Thus floating platforms for solar PV can be an important development.

b) Cage culture, biodiesel, bioenergy

Cage culture for sea food has been implemented across the globe successfully. NIOT also has had success in lobster and other species in in-house designed and fabricated open sea cages which can be seen in **Figure 6**. The technology has been transferred to coastal people in Tamil Nadu. These cages still can be developed further by automating them to go below the sea surface during storm conditions and come back up as the rough sea subsides. This will increase productivity and life of the cages. This also is being studied and being demonstrated in the open sea.

The other form of energy that needs serious consideration is bio-energy. While algal blooms are otherwise detrimental to the coastal habitat, marine algae can be used to obtain bio-diesel and several studies are underway even in CSIR laboratories on marine algae in this regard. However, these studies are still confined to the laboratory and need to be scaled up and taken to commercial levels.

3.3 Niche Areas

Apart from resources, some niche areas require technology development from civilian perspectives and not anti-warfare or defence related requirements. To this end, the following are important:

Figure 5 Hydrokinetic turbine

a) **Development of RoVs and AUVs**

Strategic applications for defence are handled by associated institutes. However, there are many civilian applications which need the development of ROVs and AUVs. Small ROVs for shallow waters are all commercially available at fairly affordable costs. However, when offshore industry starts expanding, the need for underwater inspection, repair and recovery of submerged items will start becoming important. For this, an indigenous ROV manufacturing capability is important. Such manufacturing needs industries with appropriate facilities for manufacturing as well as servicing, as also certification agencies. The market should also be developed for exporting to make it a sustainable industry.

b) **Ocean Acoustics** – Underwater acoustics is an important area since that is the only way signals can get transmitted in the ocean easily. Acoustics based equipment like SONARS have always been the domain of the navy for strategic applications. However, acoustics has other civilian applications too along with defence related sophisticated techniques for detection. We have a long way to go in developing expertise in theoretical underwater acoustics which involve intricate mathematics, as also in developing underwater instruments and sensors for imaging, detection and characterisation of the ambient noise in Indian waters. Currently, the work in acoustics is limited to a few academic ventures and in a small manner in NIOT, in addition to the naval research labs under the Ministry of Defence. This has to change to bring a large set of scientists on board for making India self-reliant.

Other related areas include indigenisation of marine instrumentation and sensors.

As can be seen, there are several areas in ocean technology which need to be addressed on a much larger scale. The National Institute of Ocean Technology has been developing several ocean related technologies in the last two decades and there is still a huge canvas for development [9].

3.4 Capacity building, training, infrastructure

As capacity building happens, market opportunities will increase as is obvious. Hence, the first step is trained manpower. For this, the existing courses in marine/ ocean engineering and ocean technology need to be augmented drastically and in turn trained teachers are the stepping stone. Universities and research organisations need infrastructure like wave basins and towing tanks to understand how vessels and offshore structures behave in the ocean. All structures in the oceans experience variable dynamic loads and are subjected fatigue. Large fatigue testing facilities, material testing equipment and high powered computers for taking up simulations using numerical wave tanks etc., are required. Job opportunities need to be linked to training programs, else there will be too may trained manpower with no jobs or jobs with

Figure 6 Sea cage culture

> **The real challenge is to have floating solar platforms in the open sea. The biggest drawback of solar PV is the large footprint required on land**

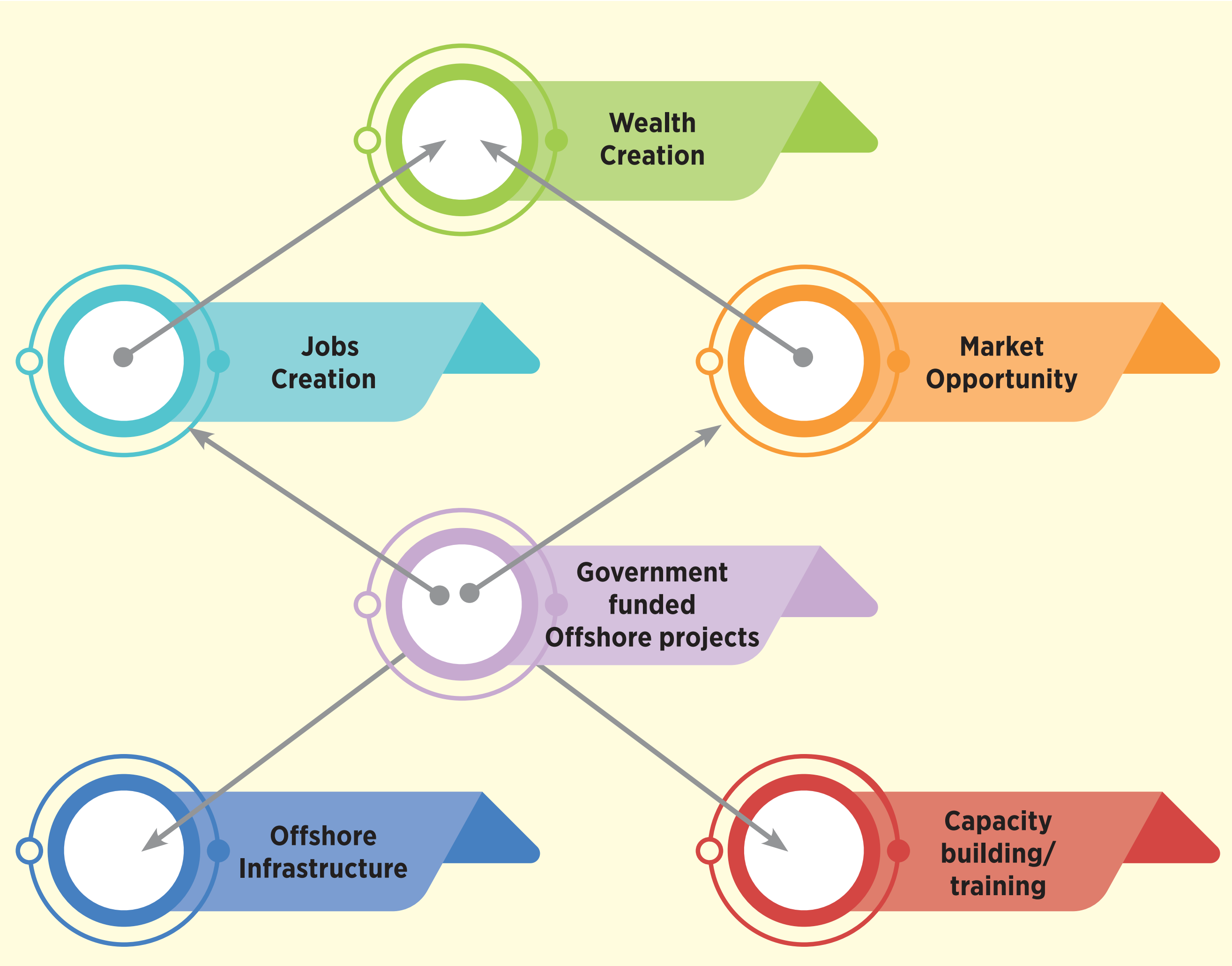

Figure7 Flow chart for wealth creation

under qualified personnel making goal achievements difficult or unprofessional.

Thus a holistic view has to be taken while planning job creation and capacity building. At the base of the pyramid is infrastructure, training and capacity building with Government funded novel offshore projects leading to jobs, thereby wealth **Figure 7.**

4.0 Conclusions

To be a world leader, India has to invest in the ocean sector specifically in the areas outlined in this article. The dependence on foreign expertise, equipment and infrastructure will be detrimental for the future. Self-reliance in the seas surrounding us in our EEZ is of utmost importance. While many possibilities exist in the ocean sector, the prioritisation is important for the country at large. Esoteric projects can probably be undertaken more for exciting young minds but the investment should be largely from the perspective of self-reliance and improving economy. Offshore engineering and ocean technology can pave the way towards a financially stronger and self-reliant India.

About the Author

Dr. Purnima Jalihal is a Senior Scientist and Head of Energy and Fresh Water Group at National Institute of Ocean Technology, Chennai. She holds a Doctorate from Duke University, USA in Civil Engineering and her research interests include renewable ocean energy, desalination, floating body and structural dynamics. Email: purnima@niot.res.in

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TECHNOLOGIES FOR NEXT GENERATION SCIENTIFIC AUTONOMOUS UNDERWATER VEHICLES

Dr. N. Vedachalam,
Dr. G. A. Ramadass

Abstract

Autonomous Underwater Vehicles (AUV) are vital for exploring the vast marine resources, spatiotemporal monitoring of the tropical and polar oceans to understand the changes in climate patterns, monitoring marine pollution, defence and identifying assets lost in the Oceans. The first part of the article summarised the challenging AUV developments hitherto, the subsystem performances and the mission capabilities.

This part brings out the hardware maturity, mission capabilities, strategic demands and the ongoing developments in achieving intelligent autonomy and swarm robotic systems essential for increasing the spatiotemporal capability. By reliability modelling and field failure data, it is estimated that the present generation AUV shall have a Mean Time to Fail period of ~4 years.

The next part discusses the requirements for realising the key technologies for next generation scientific AUV, including intervention ability, subsea homing and docking, and energy-efficient bio-inspired vehicle designs.

Index terms: AUV, bio-inspired, Homing, Intervention, Mission, Reliability, Swarm robotics.

Hardware maturity

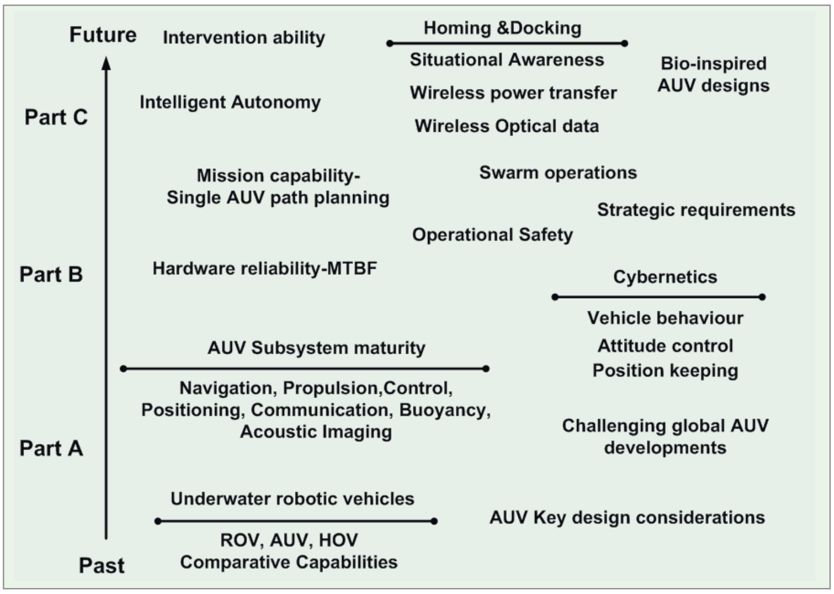
Reliability is the capability of the system to perform its intended function during the defined period. Reliability and the functional performance of the subsystems and in turn the AUV has improved over time. Based on the field reported failure rates of the subsystems/components, the reliability of the AUV functional failure is computed.

The reliability of a system is defined in Failure-In-Time (FIT), is usually represented as λ, and expressed in failures per billion hours [1]. 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,

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

The FIT for the major subsystems/ components of AUV are summarised in **Table1**. The sources of data include Failure in Time Determination for Electronics Systems (FIDES) guide [2], MILHDBF-217F [3], IEEE-493[4], DNV



Offshore Reliability Data (OREDA) handbook [5] and the Naval Surface Warfare Center (NSWC) Standard 98/LE1 for reliability prediction procedures for mechanical equipment [6].

Component	Failure rate (Failures/ billion hrs.)
Navigation System	
Inertial Navigation System-Doppler Velocity Log (INS-DVL)	12500
Depth sensor	2500
Subsea Global positioning System (GPS) receiver	2500
Satellite modem	2500
Positioning System	
Ultra-short base line (USBL) with telemetry modem	22831
Control System	
Master mission controller	6660
Propulsion System	
Thruster	500
Thruster motor power electronic speed controller	1000
Power System	
Li-Po Batteries (with 10% redundancy)	100
Battery Management System (BMS)	6660
Mechanical System	
Enclosures	2000
Seals	2440

Table1. Failure-In-Time data used for analysis [2] [3] [4] [5] [6]

Based on IEC 61508 standards [7] and functional bottom-top approach, failure trees (FT) are modeled and simulated using TOTAL GRIF reliability analysis software [8] for computing the probability of failure of the AUV. The exponential law is used for defining the degradation pattern over the simulated period.

The PoF for the AUV subsystems are shown in **Figure 1 and 2**, and the PoF of the complete AUV is shown in **Figure 3**. ***The PoF of the AUV in a period of 1 year is 22.2%, for which the Mean Time to Fail (MTTF) is ~4 years.*** Based on **Figure 3**, the contribution of the subsystems to AUV functional failure is shown in **Figure 4.**

Operational safety

In addition to the hardware reliability, operational reliability is equally important as the AUV is deployed from and recovered from the deployment vessel at various sea states. Operational risk assessment for AUV is thus based on subjective judgment and expert knowledge, as much as on hard statistics. The maturity of the operational

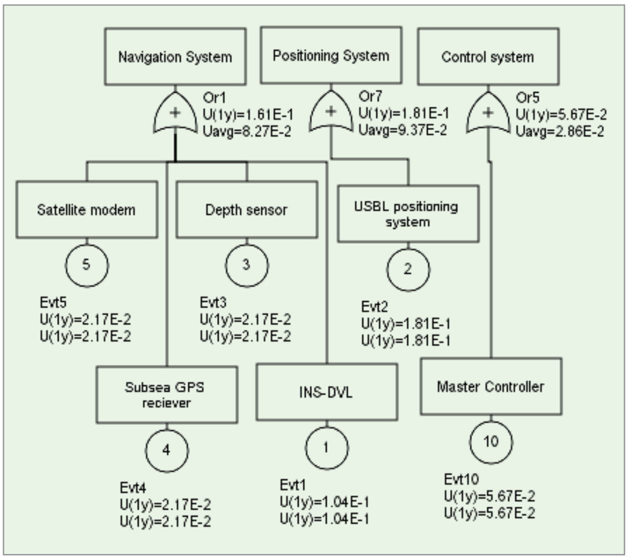


Figure 1 Failure trees showing PoF for subsystems

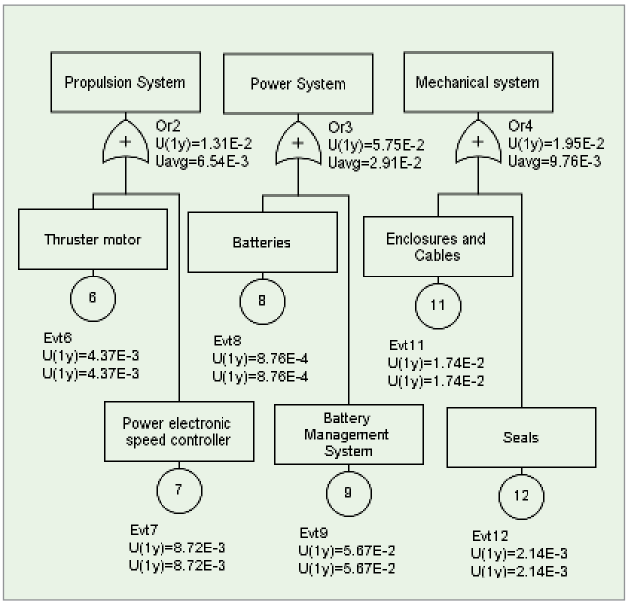


Figure 2 Failure trees showing PoF for AUV subsystems

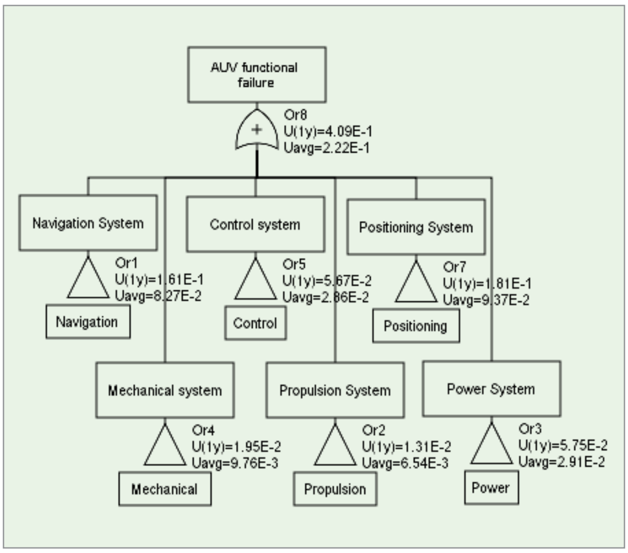


Figure 3 Failure trees showing PoF for AUV functions

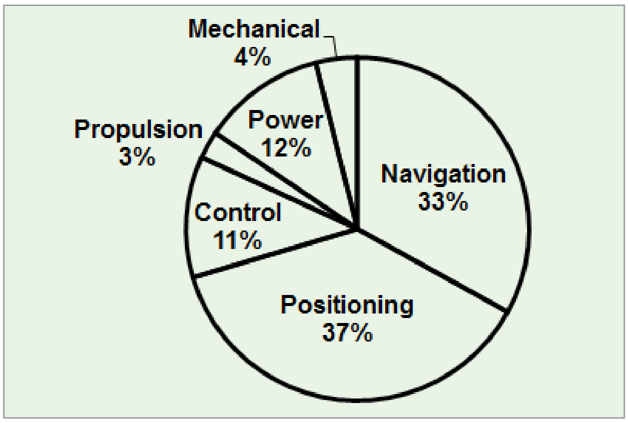


Figure 4 Contribution of subsystems to AUV functional failure

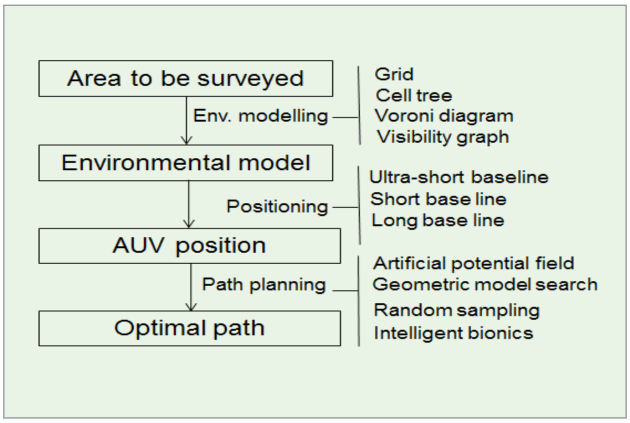


Figure 6 Requirements for way point/optimal path estimation

capabilities of AUV used in extreme environments based on a formal judgment elicitation process involving eight global experts in AUV design and operations covering 63 faults and incidents reveal that majority of the failures were during the recovery phase mainly due to collision with the ship, pre-launch faults, DVL failures, GPS antenna failures and propulsion failure [9].

These suggest the need for rugged launching and recovery systems (LARS) and reliable emergency drop weight mechanisms that helps the AUV to ascend and surface during a complete system outage and communicate its position (obtained from the on-board GPS unit) to the deployment ship through satellite telemetry.

Mission capabilities

The mission objective-based path and trajectory planning algorithms that are operational onboard the long range AUVs are presently matured. With mission objective as inputs, the generic multi-level path and trajectory planning algorithm is shown in **Figure 5**. ***The mission planning is carried out with the dedicated high level AUV master mission controller which determines the way points which serves as inputs for path planning***. The path planning algorithm provides set points to the vehicle controller which takes input from the vehicle navigation systems and other sensors.

Estimating the optimal path requires defining the limits of the AUV operating region/ underwater work

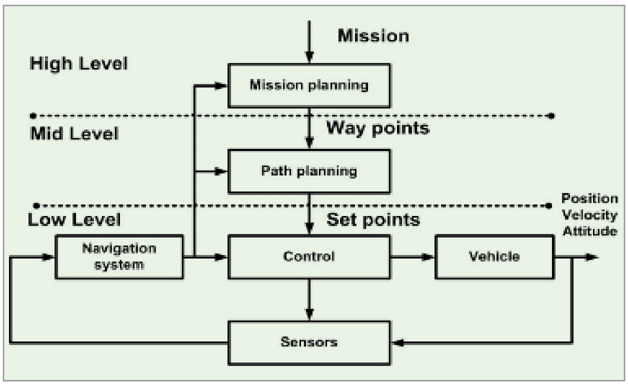
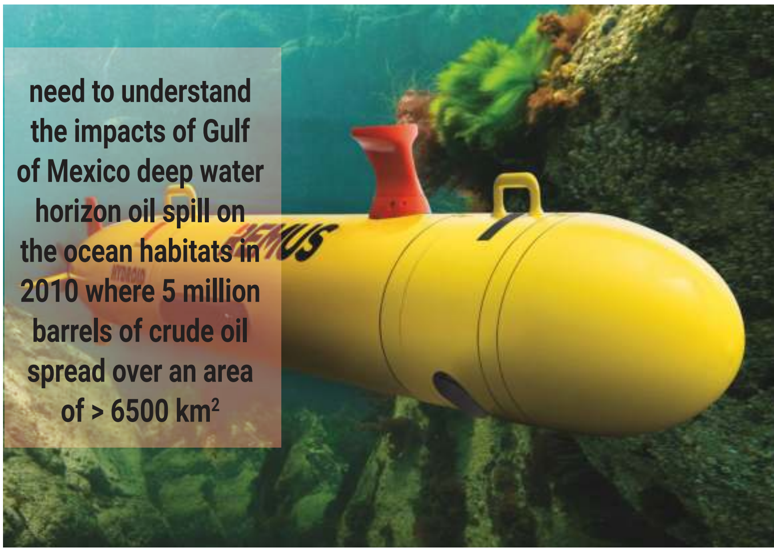


Figure 5 Path and trajectory planning algorithm

space definition, environmental model of the location and the AUV position determining mechanism **(Figure 6)**. ***Path planning is finding the course of the points across which the AUV has to travel from the starting location to the target represented as North-East-Depth (NED) coordinates.*** The time history of the journey is referred as trajectory planning.

The underwater path and trajectory planning require due consideration of the dynamic (time-varying) nature of the ocean currents, presence of obstacles and the



morphology of the seabed. The objective anisotropic cost function is to minimise the travel time/lower energy consumption and the constraints including onboard energy availability, positioning accuracy, presence of obstacles, utilising/avoiding the prevailing water currents and vehicle maneuverability limitations/agility.

Subsequent to the Dijkstra shortest path algorithm and the fast marching methods, numerous path planning algorithms are operational in various AUV. These AUV path planning algorithms fall in four categories, such as artificial potential field methods, geometric model search methods, random sampling methods, and intelligent bionic methods (**Table 2**). For effective path planning and utilisation of the AUV in predictable and unpredictable subsea environments, algorithms with inputs from

Predictable environments	Graph search, Quadratic programming, Potential field algorithm, Control vector parameterization, Galerkin method, Iterative learning, Symbolic wave front expansion (WFE), Markov planning algorithm, Multi-criteria decision analysis (MCDA).
Unpredictable environments	Graphical, Fast Marching, Non-linear trajectory generation, Evolutionary algorithm, MCDA, Iterative optimization, WFE, Random tree, Adaptive control law, Reinforcement learning, Fuzzy logic, Linear programming, Bio-inspired nuerodynamics, Shell space decomposition, Imperialist competitive algorithm.

Table 2 Path planning algorithms for single AUV

AUV vision systems (optical cameras and sonars) with on-board image processing capabilities are in use.

The AUV control is based on the kinematic non-linear function that operates based on Lyapunav theory and integrator back-stepping. They offer reliable and effective control during environmental disturbances and parametric uncertainties. The AUV dynamics is described using 6-DOF maneuvering model represented by highly-coupled and non-linear first-order ordinary differential equations containing kinetic and kinematic parts. The kinematics represents the geometrical evolution of the AUV in Euler angles (including surge, sway and heave in linear orientation, and, pitch, roll and heading/yaw in the angular orientation).

The kinetics are the forces and moments causing vehicle motion, in which, the linear forces are represented by X, Y and Z, and the angular moments by K, M and N [10]. The kinetics includes mass forces, coriolis forces, damping and restoring forces. ***Based on the changes in the AUV attitude and position, the controller dispatches the control command for generating the required propulsion thrust, rudder and control fin actuation.***

$$m[\dot{u}-vr+wq-x_G(q^2+r^2)+y_G(pq-\dot{r})+ z_G(pr+\dot{q})]=X$$

$$I_x\dot{p}+(I_z-I_y)qr-\left(\dot{r}+pq\right)I_{xz}+\left(r^2-q^2\right)I_{yz}+\left(pr-\dot{q}\right)I_{xy} +m\left[y_G\left(\dot{w}-uq+vp\right)-z_G\left(\dot{v}-wp+ur\right)\right]=k$$

The AUV control functions are based on Proportional-Derivative (PD), sliding mode and fuzzy logic. The recent deep reinforced machine learning (DRL) controllers are developed using algorithms that can learn to execute tasks by reinforcing actions based on performance metrics. The DRL controllers with reward function offers very impressive results in achieving the combined objective of following the path and avoiding collision.

Strategic demands

The strategic requirement demands AUV with higher spatiotemporal capabilities, energy efficiency, agility and improved maneuverability. The demanding requirement are evident from the challenging events such as the searches undertaken to locate the US sunken Thresher and Scorpion submarines in the Northern Atlantic in 1960s; need to understand the impacts of Gulf of Mexico deep water horizon oil spill on the ocean habitats in 2010 where 5 million barrels of crude oil spread over an area of > 6500 km^2; searching the wreckage of lost aircraft AF447 in the mid-Atlantic ridge over 8000 km^{2}in water depths up to 4300mand locating the same after 22 months of disappearance over a 600 x 200m location based on the

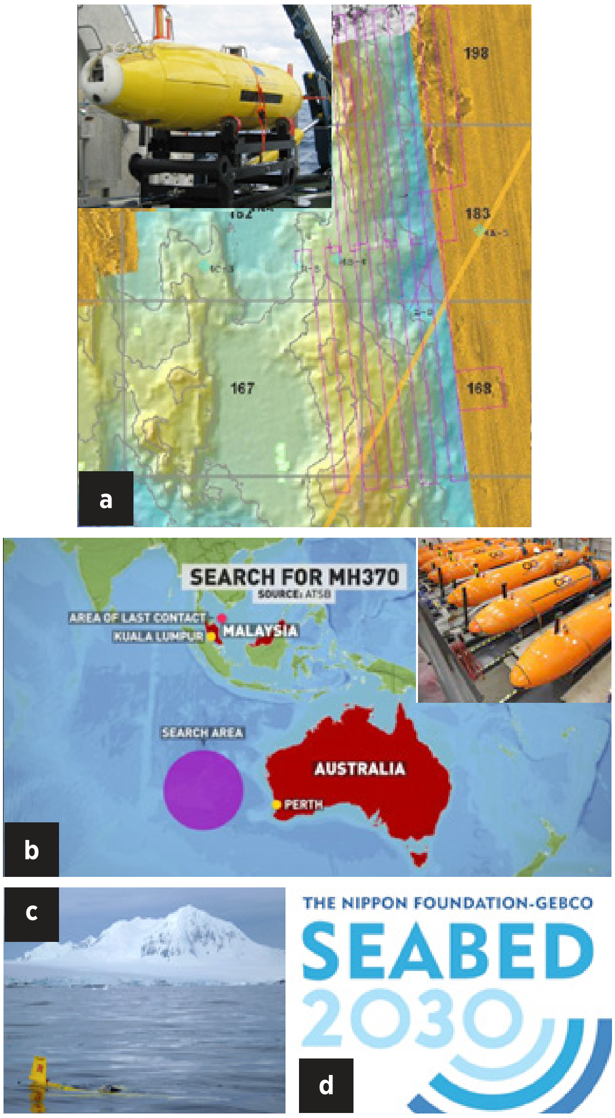


Figure 7 (a) Search for AF447 by REMUS AUV (b) MH370 search by Hugin (c) Polar challenge (d) Seabed 2030 initiative

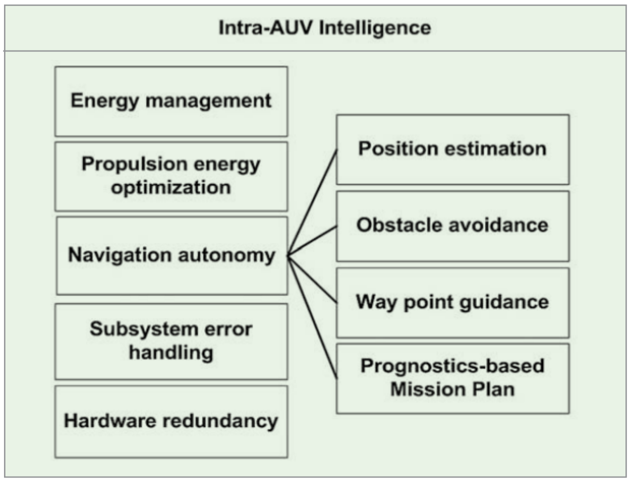


Figure 8. Framework of implementing intelligent autonomy

image mosaics obtained from the 18th REMUS AUV mission in 2011 (**Figure 7 a**); the US$ 0.2 billion efforts expended in mapping about 1 million km^2 of the deep seabed for locating the wreckage of the Indian Ocean-lost MH370 aircraft in 2014***; the 90-day US$ 93 million challenge undertaken by the US-based seabed exploration firm Ocean Infinity in locating the lost Malaysian airliner MH370 over 25000 km^{2}seabed area in the southern Indian ocean using eight AUVs at 5600 m water depths with a target covering 1200 km^{2}of seabed/day*** (**Figure 7 b**).

The time-bound wide area search of the ocean-lost aircraft's underwater location beacon operating at 37.5 kHz with a limited transmitter source pressure level 160db re 1µPa@1m covering a limited range of a few kilometers and with an energy endurance of 90 days makes the search operations challenging.

The recently announced Polar challenge by the World Ocean Council involving the 2000 km continuous under ice mission in Arctic and Antarctica (**Figure 7 c**); the challenging deep ocean mineral mining needs that requires precise high resolution mapping of the vast poly-metallic nodule and cobalt crust fields; and the ongoing Seabed 2030 project aimed to create a full global sea floor map by 2030 with a 100m resolution (**Figure 7 d**) [11] [12].

Next generation AUV technologies

Intelligent autonomy

Intelligent Autonomy (IA) is the ability of the AUV to sense, interpret, and act upon unforeseen changes in the environment and the vehicle itself. The framework of the IA (**Figure 8**) encompasses intelligent decision-making capabilities in navigation, energy management and system error handling.

Navigation autonomy reduces the vehicle dependence on the acoustic position aid from a surface vessel and the frequency of global positioning system (GPS) surface fixes. Navigation autonomy includes obtaining precision vehicle velocity information from multiple sources which is vital for position estimation, obstacle avoidance for vehicle safety with the information processed from the sonar and on-board cameras, way point guidance based on pre-programmed targets, and an efficient mission plan factoring-in the vehicle prognostics information such as the battery status and health of the other vehicle subsystems.

The navigation autonomy algorithm plays a very vital role in obtaining reliable and most accurate vehicle velocity from the available sensors with the aid of the Kalman predictor-corrector algorithms and on-board vehicle velocity models required for estimating vehicle position in dead-reckoning mode (**Figure 9**).

While diving to deep waters, based on the depth information, the DVL has to be commanded to operate in either bottom tracking or water tracking mode, and when the DVL is out of its operation region, accelerometer inputs are to be used. In the Polar under-ice navigation, the vehicle may have to start in open water where DVL cannot initially sense with respect to the ice, then it may have to pass under broken ice cover during the mission where it takes the inputs from the inverted DVL, while lack of back scatter due to less zooplankton could be challenging for the DVL to provide reliable velocity information in water tracking mode.

In the absence of or in addition to the DVL and inertial measurements, navigation autonomy algorithm has the models to infer velocity based on indirect techniques. The techniques include using the kinetic vehicle model for predicting the water-relative velocity, terrain navigation method based on correlating the bathymetric measurements with the pre-obtained digital terrain model of the sea floor, simultaneous localisation and mapping (SLAM), macro-delta position aiding based on estimating the position from the two observation instances, and cooperative data exchanges with the adjacent vehicles, if any. The velocity measurements obtained from one or more techniques are integrated with the INS with the aid of predictor-corrector algorithms aided by Kalman filters.

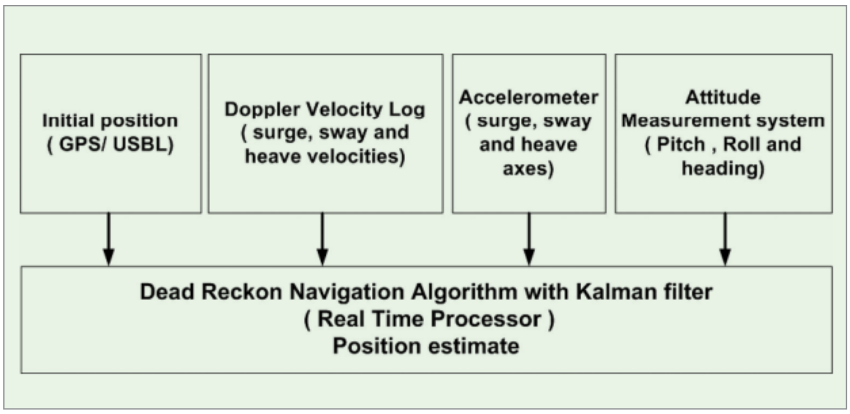


Figure 9. Vehicle position estimation dead reckon algorithm [13]

Energy and subsystem autonomy

Energy autonomy and failure tolerance during vehicle subsystem outages, malfunctions, degradations and failures are vital for the success of long endurance missions. ***The residual energy in the battery serves as a crucial input to the mission plan for the AUVs deployed in unknown and dynamic environmental conditions***. The propulsion energy requirements, in addition to the vehicle velocity and the payload, depend on the vehicle buoyancy changes with water depth. Vehicles with net buoyancy require a corresponding lifting force to counteract that buoyancy force while servoing the desired depth.

The density of the seawater varies 2.8% over the 6000m range. If the materials used in the construction of AUV do not compress at a similar rate, the buoyancy of the vehicle changes substantially as it descends. Experiences from the AUTOSUB report a buoyancy variation of 20–26 kg from surface to 4500 m water depth. For a propeller driven vehicle diving/depth keeping is achieved by pitching the vehicle, resulting in the required lift force but also increasing the vehicle drag, termed as the lift induced drag.

The energy lost to lift induced drag constitutes as either additional propulsive energy needed to maintain the same speed or as a loss in speed in constant propeller speed scenario resulting in reduced range. Thus, the state of charge of the battery is the most important input for autonomous re-planning of the vehicle mission and implementing navigation autonomy.

Battery packs are equipped with battery management systems (BMS) that provide inputs to the navigation controller to realize an in-situ efficient and reliable mission plan. The availability of the AUV subsystems could be increased by redundancy with a reasonable trade-off between the vehicle dimensions and weight. Redundant on-board real-time controllers operated in the master-slave configuration with optimized power consumption strategies help improve the reliability of the AUV. Software codes segregated into normal process, diagnostics and emergency helps in increasing the reliability of the control system firmware.

Swarm capabilities

Operating multiple AUV in a coordinated manner is required to carry out fine to mesoscale observations such as effective subsea mapping and search operations. Subsea operations are limited by onboard energy endurance of the AUV and the formation is determined by the physical dimensions of the seafloor object to be detected, which is function of the scanning system resolution In the vast ocean, the probability of finding a target within the specified search area A, defined in below equation, indicates that, by increasing the survey sweep area, the probability of identifying the target could be advanced [12].

$$\text{Probability of finding the target} = 1 - e^{W.L/A}$$

where, W.L is the swept area in unit time.

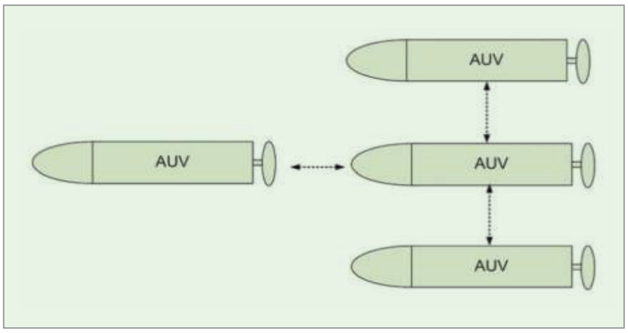


Figure 10. AUVs operated in swarm mode

When multiple AUVs are involved in the spatial mapping of physical or chemical entities in a vast ocean, the AUVs shall exchange the mapped parameters with their peers so that the trajectories of the other peers (**Figure 10**) could be planned accordingly to optimize the search/ survey time.

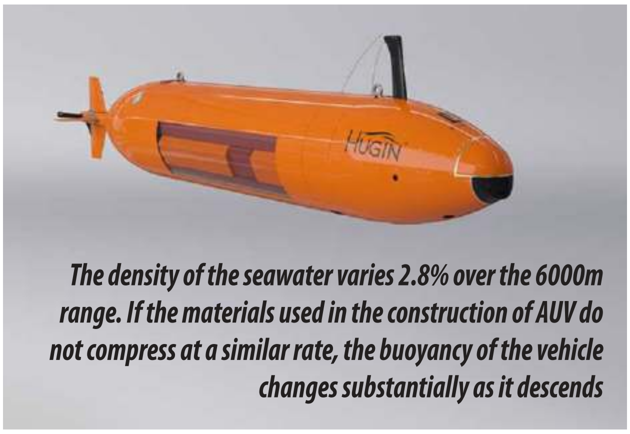
Subsea swarm robotics systems (SRS) is a system of multiple subsea robots that take inspiration from the spatial self-organizing, navigation behavior and collective decision making behavior of social animals [12]. SRS comprises several relatively simple agents interacting only locally within themselves and with their environment, without having a global knowledge about their own state and of the state of the world. Hence ***SRS helps in realizing efficient, robust, scalable and flexible multi-AUV configuration***.

The basic requirements for SRS implementation (**Figure 11**) requires effective position determination capability by individual AUV, seamless inter AUV communication and intelligent swarm intelligence algorithms. The path and trajectory planning algorithms for multiple AUVs is under development for operating in predictable and unpredictable subsea environments are summarized as in **Table3.**

When the AUVs are operating in swarm mode, exchange of information among the swarm peers could help in implementing advanced cooperative control mechanisms

Predictable environments	Fuzzy logic, Time-coordinated path planning, Evolutionary algorithm, Line-of-sight, Lagrangian multipliers, Long base line methods.
Unpredictable environments	Virtual bodies and artificial potentials, Cooperative control method, Leader-follower structure, Markov decision process, Neural network, Ant colony optimization, Greedy approach, dynamic programming, Rapidly exploring random tree.

Table 3 Path planning algorithms for multiple AUV



The density of the seawater varies 2.8% over the 6000m range. If the materials used in the construction of AUV do not compress at a similar rate, the buoyancy of the vehicle changes substantially as it descends

including flocking, navigating, searching, path formation, collaborative manipulation, and task applications implementable based on the swarm behaviors of bacterial colonies, fish schools, ant colonies, bird navigation and human behavior.

This helps in increasing the swarm efficiency, parallelism, scalability and robustness. Various cooperative algorithms are reported recently such as wave algorithm applied to swarm navigation, leader-follower approach, coordinated control approach and feature detection. ***Adaptive intelligence could help to overcome unexpected uncertainties in the marine environment such as during the influence of water currents which may cause a significant deviation from the desired trajectory or a severe distortion in the desired formation structure that can eventually result in loss of communication within the AUV network.***

In the case of time-bound search operations involving optimisation by searching in a large set of feasible solutions, meta-heuristics offer effective solutions at reduced computational effort compared to conventional optimization algorithms, iterative methods and simple heuristics. Meta-heuristic algorithms include genetic evolution based, stochastic, physics-related, probabilistic, fuzzy logic, immune, neural and swarm intelligence types.

The nature-inspired meta-heuristic algorithms applied in SRS include Particle Swarm Optimization (PSO), river formation dynamics, Ant Colony Optimization (ACO), artificial bee colony, bacterial foraging optimisation, altruism algorithm, firefly algorithm, cuckoo search, intelligent water drops, krill herd, coral reef, invasive weed colonisation, harmony search, flower pollination spread, bat-inspired and brain storm optimisation algorithms.

The ACO algorithm is based on the foraging behavior of ant colonies in finding short paths, brood sorting, division of labor and cooperative transport [14]. ***The popular PSO is a population-based stochastic optimization technique based on the principles of bird flocking or fish schooling principles, in which each AUV maneuvers based on its own experience and the experiences of its neighbors.*** As per PSO algorithm, each AUV tries to modify its position by using its current position, current speed, distance between its current, best and global positions, which is defined as

x_k^i - AUV position, i is the index, k is the iteration

v_k^i - AUV velocity

p_k^i - Best "remembered" individual AUV position

p_k^g - Best "remembered" swarm position

C_1, C_2 – Cognitive acceleration co-efficient parameters

r_1, r_2 – Random numbers between 0 and 1

Position of individual AUVs updated as follows with sampling time 1s.

$$x_{k+1}^i = x_k^i + v_{k+1}^i$$

With the velocity of individual AUVs updated as follows with the individual AUV and global environment as shown below

$$v_{k+1}^i = v_k^i + c_1 r_1 \left(p_k^i - v_k^i\right) + c_2 r_2 \left(p_k^g - x_k^i\right)$$

In a dynamic PSO, the parameters are refreshed synchronously through a communication mechanism throughout the network during the searching process. The PSO algorithms are implemented in synchronous, asynchronous and parallel PSO's depending on the application by considering the resources, operational time, sensor system limitations and other constraints.

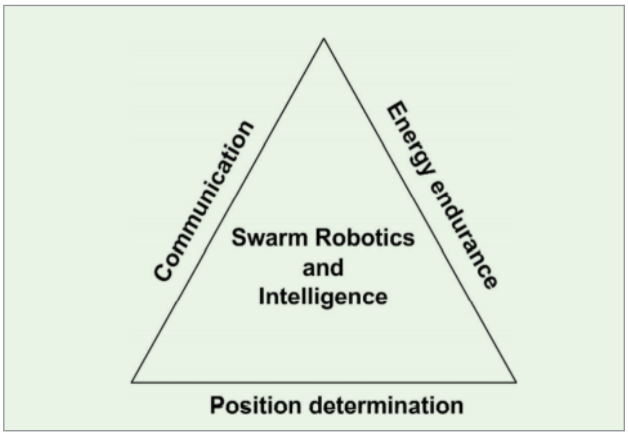


Figure 11. Requirements for implementing efficient subsea SRS

Conclusions

The technological advancements in the high energy density battery storage, underwater navigation sensors, processing electronics, underwater navigation algorithms, high density buoyancy packs and lighter high-strength pressure casings supported by modern numerical modeling tools have enabled development of novel autonomous underwater vehicles capable of carrying out scientific exploration in impractical hostile environments. The strategic demand in the oceanography, glaciology, marine research, defense, engineering construction domains require further energy-efficient, agile and intelligent autonomous underwater vehicles with increased spatio-temporal capability capable of navigating thousands of kilometers in the deep oceans and Polar Regions.

In the last issue focused on the developments in unmanned and manned underwater vehicle technologies, potential applications in the offshore sector and the performances of the state-of-the-art subsystems. In this issue, the level of maturity of the present generation autonomous underwater vehicles in terms of mean time between failure, operational safety, mission capabilities, strategic requirements, and ongoing developments towards achieving intelligent autonomy in navigation, energy management and mission planning are detailed.

The need and the technological trends in the upcoming developments in swarm robotic systems are explained. The next issue covers the futuristic requirements including the need for increased synergy in realizing true swarm capabilities, intervention abilities, subsea homing and docking with wireless power and optical data transfer features, and energy-efficient bio-inspired vehicle designs for strategic-grade autonomous underwater vehicles.

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ENVIRONMENTAL SHIPPING AND THE GLOBAL CLIMATE CHANGE CHALLENGES

Dr. Jai Acharya

Abstract

Climate change is one of the greatest challenges facing our societies, economic structures and environmental systems. As a significant risk multiplier, climate change undermines the objectives of sustainable development by exacerbating other interconnected global problems, including poverty, food shortages, water scarcity, energy insecurity and environmental degradation. Within the transport sector, the special case of seaports calls for particular attention. With over 90 per cent of world trade by volume being carried by sea, ports fulfil a critical function as links of global supply chains and constitute engines of economic growth. At the same time, these key infrastructural assets are vulnerable to climate change impacts and associated risks, given their location in coastal zones, low-lying areas and deltas.

Though mitigation action in maritime transport is critical, it is not sufficient to effectively address climate change and its related impacts. Adaptation action based, as a prerequisite, on a good understanding of risks and vulnerabilities is fundamental to help minimise the effects of unmitigated climate change on maritime transport and trade. While adaptation of tangible action in maritime transport is increasingly recognised as important, it should be noted that it is a newcomer to the climate change policy debate and has so far attracted much less interest than mitigation.

A Sustainable Maritime Transportation System needs efficient port facilities to keep the operational efficiency of ships at the highest level. Hull cleaning and propeller polishing facilities, specialised fuel and power supply services are the integral part of these facilities. The logistics infrastructure should allow ships to sail at optimal speeds for their charted trajectories (e.g. cargo logistics and port planning, just-in-time berthing, weather routeing). All these elements would form part of a "holistic" energy efficiency concept for the whole system.

Keywords: Environmental Shipping, IMO, Emissions, Climate change, SRES, Energy Efficiency

Environmental Shipping

Transportation and the greenhouse gas (GHG) emissions are at the centre stage of the current climate change debate. While the entire sector needs to reduce its carbon footprint, international shipping, in particular, has attracted attention because the GHG emissions generated by this sector are not covered under the United Nations Framework Convention on Climate Change (UNFCCC). Another reason for this heightened interest is the renewed opportunity provided by the current climate negotiations under UNFCCC and IMO to adopt, for the first time, a binding international regime.

Some regulatory measures focusing on technical and operational aspects of international shipping have recently been adopted by IMO while other measures, such as market-based instruments, are still being considered. Mitigation action is also gathering momentum among the shipping and port industries with a number of measures already implemented or planned.

Maritime Transportation and Environmental Risks

Risks for maritime transport include accelerated coastal erosion, port and coastal road inundation or submersion, increased runoff and siltation requiring increased dredging, restrictions on access to docks, deterioration of conditions and problems with the structural integrity of pavements and railway tracks within port areas and related hinterland connections.

In addition to these impacts on physical infrastructure, climate change also affects shipping volumes and costs, cargo loading and capacity, sailing and/or loading schedules, storage and warehousing. These impacts are likely to impose costs that will be correlated to the degree of exposure and vulnerability, as well as constraints on the adaptive capacity. Furthermore, greater global interconnectedness and economic integration with supply chains acting as transmission channels entail additional costs. A localised impact on ports can have ripple effects that extend beyond borders to affect industries, stakeholders and economies in distant locations. Although not necessarily driven by climate change, supply chain disruptions resulting from damage to ports caused by natural disasters in Japan and Thailand in 2011 provide a poignant illustration.

The implications of any damage or disruption to transport networks, including ports, can be particularly challenging for the transport and trade of developing countries such as Small Island Developing States (SIDS). The challenge for SIDS is of greater magnitude given their high economic, geographic and climatic vulnerabilities and their generally limited adaptive capacity. In this context, building the capacities of developing countries, including SIDS, with a view to reducing their vulnerability and managing disaster risks is crucial and should be pursued as a matter of priority.

Assessing the costs for ports and their hinterland connections associated with the impacts of climate change is difficult with any certainty. There is no doubt, however, that these impacts can reach extreme proportions in ports and port cities. A study by OECD assessed the exposure of the world's largest port cities to coastal flooding in 2005 and has estimated the total value of assets exposed across all 136 port cities examined to be $3 trillion.

A more recent study examining the same 136 port megacities has found that, assuming a sea-level rise of 0.5 metres by 2050, the value of exposed assets may be as high as $28 trillion. These costs are rising in tandem with ever increasing urbanisation, population growth, investment in port and transport infrastructure, and wealth expansion around coastal areas.

Current Scenario on Adopted Strategies

Against this background, the case for designing and implementing appropriate adaptation strategies to address climate-change impacts on transport, and more specifically on ports, is a strong one. Given the long lifetime of transport infrastructure, adaptation has to happen now to avoid high retrofitting costs. However, a review of the available literature reveals that adaptation action in ports appears to be scarce.

Over recent years, various studies have addressed the impacts of climate change on transportation infrastructure generally, for example in the case of the United States, Canada, Australia and the United Kingdom. Most of these studies, however, are not mode-specific

and very few specifically focus on ports. Within the existing literature available in the public domain, the United States report, Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I, is of particular relevance for ports and their hinterland connections. Other studies worth noting include the report commissioned by the International Finance Corporation (IFC), which focuses on the case of the Terminal Maritimo Muelles el Bosque (MEB), in Cartagena, Colombia. The aim of this study was to help develop knowledge, tools and methods for analysing climate-related risks and opportunities, and for evaluating adaptation responses. Equally relevant is the study commissioned by the International Association of Ports and Harbours (IAPH), Seaports and Climate Change - An Analysis of Adaptation Measures.

While adaptation strategies in ports may vary (for example, retreat/relocate, protect, and/or accommodate), the ultimate objective is to enhance the resilience of facilities and systems. This may be achieved by, for example, changes in operations, management practices, planning activities, design specifications and standards. This may involve integrating climate change considerations into transport and port investment and planning decisions, as well as into broader transport and port design and development plans.

A number of factors could, nevertheless, potentially delay or pose challenges to adaptation action. Firstly, as ports involve multiple players in the decision-making process, it may be difficult to proceed effectively with adaptation plans and strategies. Secondly, factors such as a high perception of uncertainty, limited information about the cost-effectiveness of adaption options and about the cost of inaction, the need for realistic predictions of impacts and for science-based policy formulation that takes into consideration the specifics of the region, and resource intensiveness and costs could all, either individually or in combination, hamper adaptation action in ports.

More specifically, costs and the constraints of financial resources could pose a great challenge to adaptation action. Existing studies on adaptation costs provide only a wide range of estimates and have many information gaps. Much more knowledge is required regarding the impacts of climate change and how they interact, and regarding information on relevant adaptation options. A study not specific to transport or ports produced by the World Bank estimates that for developing countries, the cost of adapting to an increase in temperature by approximately 2°C by 2050 would be, for the period 2010-2050, in the range of $75 billion - $100 billion annually.

Special Report on Emissions Scenarios (SRES) and Climate Change Initiatives

Estimates for Barbados that are more specific for transportation, based on the Inter-governmental Panel on Climate Change (IPCC) emission projection scenarios SRES B2 and SRES A2, indicate that by 2050, the total impact of climate change on international transport expenditures could range from $12.7 billion (scenario SRES B2) to $14.9 billion (scenario SRES A2). The costs for maritime transportation alone range between $2 billion (SRES B2) and $2.6 billion (SRES A2). Another study has estimated the total costs of climate change for international transportation in Montserrat to be between $839 million and $1.1 billion under scenarios SRES B2 and SRES A2, respectively, while, for maritime transport, estimates amounted to between $209 million (SRES B2) and $347 million (SRES A2).

Nevertheless, the benefits of adaptation in terms of the effects on frictions to international trade and development are expected to outweigh the costs. One study which compared the cost of adaptation with the cost of inaction at the European Union level finds that by 2020, the net benefit of adaption will range between €3.8 billion (low sea-level-rise scenario) and €4.2 billion (high sea-level-rise scenario). These benefits are expected to increase further by 2080.

Adoption of scenario families

A summary of the scenarios is projected in **Table 1**.

A1

The A1 scenarios are of a more integrated world characterised by

- Rapid economic growth.
- A global population that reaches 9 billion in 2050 and then gradually declines.
- The quick spread of new and efficient technologies.
- A convergent world - income and way of life converge between regions. Extensive social and cultural interactions worldwide.

There are subsets to the A1 family based on their technological emphasis:

- A1FI - An emphasis on fossil-fuels (Fossil Intensive).
- A1B - A balanced emphasis on all energy sources.
- A1T - Emphasis on non-fossil energy sources.

A2

The A2 scenarios are of a more divided world characterised by

- A world of independently operating, self-reliant nations. Continuously increasing population.
- Regionally oriented economic development.

B1

The B1 scenarios are of a more integrated, more ecologically friendly world characterised by:

- Rapid economic growth as in A1, but with rapid changes towards a service and information economy.
- Population rising to 9 billion in 2050 and then declining as in A1. Reductions in material intensity and the introduction of clean and resource efficient technologies.
- An emphasis on global solutions to economic, social and environmental stability.

B2

The B2 scenarios are of a more divided, but more ecologically friendly world characterised by:

- Continuously increasing population, but at a slower rate than in A2.
- Emphasis on local rather than global solutions to economic, social and environmental stability.
- Intermediate levels of economic development.
- Less rapid and more fragmented technological change than in A1 and B1.

AR4	More economic focus	More environmental focus
Globalisation	A1 Rapid Economic Growth (Groups: A1T; A1B; A1F1) 1.4 - 6.4°C	B1 Global Environmental Sustainability 1.1 - 2.9°C
Regionalisation	A2 Regionally Oriented Economic Development 2.0 - 5.4°C	B2 Local Environmental Sustainability 1.4 - 3.8°C

Table 1 Four SRES Scenario Families of the Fourth Assessment Report vs. Projected Global Average Surface Warming Until 2100] –

(Ref. Source: IPCC Climate Change Synthesis Report 2007)

Case	Temperature change (°C at 2090–2099 relative to 1980–1999) [a, d]		Sea level rise (m at 2090–2099 relative to 1980–1999)
	Best estimate	**Likely range**	**Model-based range excluding future rapid dynamical changes in ice flow**
Constant year 2000 concentrations	0.6	0.3 – 0.9	Not available
B1 scenario	1.8	1.1 — 2.9	0.18 — 0.38
A1T	2.4	1.4 — 3.8	0.20 — 0.45
scenario B2	2.4	1.4 — 3.8	0.20 — 0.43
scenario	2.8	1.7 — 4.4	0.21 — 0.48
A1B	3.4	2.0 — 5.4	0.23 — 0.51
scenario A2	4.0	2.4 — 6.4	0.26 — 0.59
scenario			
A1FI			
scenario			

Table 2: Projected global average surface warming and sea level rise at the end of the 21st century.
(Ref. Source: IPCC Climate Change Synthesis Report 2007)

In the Climate Change Synthesis Report (2007) of IPCC, the temperatures are assessed as best estimates and likely uncertainty ranges from a hierarchy of models of varying complexity as well as observational constraints. The Year 2000 constant composition is derived from Atmosphere-Ocean General Circulation Models (AOGCMs) only.

All scenarios above are six SRES marker scenarios. Approximate CO2-eq concentrations corresponding to the computed radiative forcing due to anthropogenic GHGs and aerosols in 2100 for the SRES B1, AIT, B2, A1B, A2 and A1FI illustrative marker scenarios are about 600, 700, 800, 850, 1250 and 1550ppm, respectively.

Temperature changes are expressed as the difference from the period 1980–1999. To express the change relative to the period 1850 – 1899 add 0.5°C. This is assumed to be similar for the current times and will be adjusted in due course.

Schematic Illustration of SRES Scenarios

Four qualitative storylines yield four sets of scenarios called "families": A1, A2, B1, and B2. Altogether 40 SRES scenarios have been developed by six modelling teams. All are equally valid with no assigned probabilities of occurrence. The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterising alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel). Within each family and group of scenarios, some share "harmonised" assumptions on global population, gross world product, and final energy. These are marked as "HS" for harmonised scenarios. "OS" denotes scenarios that explore uncertainties in driving forces beyond those of the harmonised scenarios. The number of scenarios developed within each category is shown. For each of the six scenario groups, an illustrative scenario (which is always harmonised) is provided. Four illustrative marker

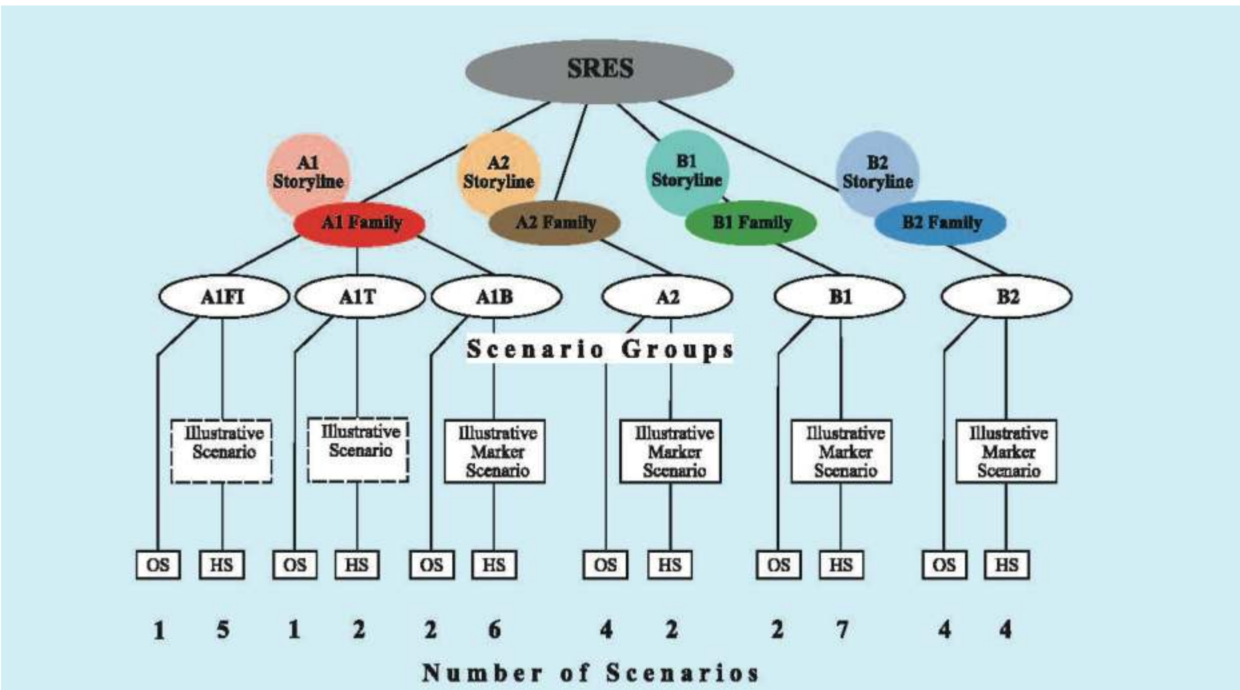

Figure 1: The main characteristics of the four SRES storylines and scenario families
[Ref. Source: Special Reports on Emission Scenarios (SRES) – 2000, Nebojsa et al. (2000)]

scenarios, one for each scenario family, were used in draft form in the 1998 SRES open process and are included in revised form in this report. Two additional illustrative scenarios for the groups A1FI and A1T are also provided and complete a set of six that illustrate all scenario groups. All are equally sound.

By 2100, the world would have changed in ways that are difficult to imagine - as difficult as it would have been at the end of the 19th century to imagine the changes of 100 years since. Each storyline assumes a distinctly different direction for future developments, such that the four storylines differ in increasingly irreversible ways. Together they describe divergent futures that encompass a significant portion of the underlying uncertainties in the main driving forces. They cover a wide range of key "future" characteristics such as demographic change, economic development, and technological change. For this reason, their plausibility or feasibility should not be considered solely on the basis of an extrapolation of current economic, technological, and social trends.

- The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).
- The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.
- The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.
- The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

IMO strategy to reduce GHG emissions from shipping

IMO continues to contribute to the global fight against climate change, in support of the UN Sustainable Development Goal 13 (SDG 13) to take urgent action to combat climate change and its impacts.

IMO has adopted mandatory measures to reduce emissions of greenhouse gases from international shipping, under IMO's pollution prevention treaty (MARPOL) - the Energy Efficiency Design Index (EEDI) mandatory for new ships, and the Ship Energy Efficiency Management Plan (SEEMP).

By 2100, the world would have changed in ways that are difficult to imagine - as difficult as it would have been at the end of the 19th century to imagine the changes of 100 years since

In 2018, IMO adopted an initial IMO strategy on reduction of GHG emissions from ships, setting out a vision which confirms IMO's commitment to reducing GHG emissions from international shipping and to phasing them out as soon as possible.

In October 2018 (MEPC 73), IMO approved a **follow-up** programme, intended to be used as a planning tool in meeting the timelines identified in the initial IMO strategy. The streams of activity identified in the programme of follow-up actions include:

1. Short-term measures (Group A) that can be considered and addressed under existing IMO instruments;
2. Short-term measures (Group B) that are not work in progress and are subject to data analysis;
3. Short-term measures (Group C) that are not work in progress and are not subject to data analysis;
4. Mid-/long-term measures and action to address the identified barriers;
5. Impacts on States;
6. Fourth IMO GHG Study - initiated in 2019;

7. Capacity-building, technical cooperation, research and development; and
8. Follow-up actions towards the development of the revised Strategy – set to be adopted in 2023.

Initial IMO GHG strategy

The initial GHG strategy envisages, in particular, a reduction in carbon intensity of international shipping (to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008); and that total annual GHG emissions from international shipping should be reduced by at least 50% by 2050 compared to 2008. The strategy includes a specific reference to "a pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals".

The initial strategy represents a framework for Member States, setting out the future vision for international shipping, the levels of ambition to reduce GHG emissions and guiding principles; and includes candidate short-, mid- and long-term further measures with possible timelines and their impacts on States. The strategy also identifies barriers and supportive measures including capacity building, technical cooperation and research and development (R&D).

The strategy envisages that a revised strategy will be adopted in 2023. Feeding in to the process towards the adoption of the revised Strategy in 2023 will be the data collection system on fuel oil consumption of ships over 5,000 gross tons, which began on 1 January 2019.

Levels of ambition in the strategy

The Initial Strategy identifies levels of ambition for the international shipping sector noting that technological innovation and the global introduction of alternative fuels and/or energy sources for international shipping will be integral to achieve the overall ambition. Reviews should take into account updated emission estimates, emissions reduction options for international shipping, and the reports of the Intergovernmental Panel on Climate Change (IPCC). Levels of ambition directing the Initial Strategy are as follows:

1. Carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships to review with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;
2. Carbon intensity of international shipping to decline to reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and
3. GHG emissions from international shipping to peak and decline to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals.

The Paris Agreement on climate change was agreed in 2015 by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and entered into force in 2016. The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2OC above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5OC (degrees Celsius). The Paris Agreement does not include international shipping, but IMO, as the regulatory body for the industry, is committed to reducing greenhouse gas emissions from international shipping.

Cooperation with ports to reduce emissions from shipping

MEPC 74 (May 2019) adopted resolution MEPC.323(74) on Invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions from ships.

This could include regulatory, technical, operational and economic actions, such as the provision of: Onshore Power Supply (preferably from renewable sources); safe and efficient bunkering of alternative low-carbon and zero-carbon fuels; incentives promoting sustainable low-carbon and zero-carbon shipping; and support for the optimisation of port calls including facilitation of just-in-time arrival of ships.

The Global Industry Alliance to support low carbon shipping (GIA), operating under the auspices of IMO's GloMEEP project, has recognised the key role of ports in the decarbonisation of shipping. In particular, just-in-time (JIT) operation of ships has a potential to reduce emissions. The GIA has been gathering experience from ports that have successfully (or unsuccessfully) implemented JIT; has been analysing barriers; and has been studying concrete measures for removal of these barriers to large-scale uptake of JIT.

Short term measures – reduced speed operations

The initial GHG strategy adopted by IMO includes a range of candidate short-term measures (e.g., considering and analysing the use of speed optimisation; speed reduction etc.), taking into account safety issues, distance travelled, distortion of the market or to trade and that such measure does not impact on shipping's capability to serve remote geographic areas. The guidelines for the mandatory Ship Energy Efficiency Management Plan (SEEMP) already refer to "speed optimisation" as a potential approach to improve the energy efficiency of the ship, recognising that speed optimisation can produce significant savings.

IMO's zero carbon strategy ambition

In the initial IMO strategy, there is a clear ambition to pursue efforts towards phasing out GHG emissions from international shipping entirely, by the end of this century. This has to become a reality. It is clear that the global introduction of alternative fuels and/or energy sources for international shipping will be integral to achieve the overall ambitions set out in IMO's initial strategy for reducing GHG emissions from international shipping. There is room for all options to be considered, including electric and hybrid power, hydrogen and other fuel types.

As UN Secretary-General Antonio Guterres has said, "We need to put the brake on deadly greenhouse gas emissions and drive climate action.5 The world is counting on all of us to rise to the challenge before it's too late". Research and development will be crucial, as the targets agreed in the IMO initial strategy will not be met using fossil fuels. There is a need to make zero-carbon ships more attractive and to direct investments towards innovative sustainable technologies and alternative fuels.

[Ref: http://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx]

Mid term strategy in the coming 2 to 3 decades

Some of the things that have been identified in the GHG strategy include looking at the provision of ship and shore-side/on-shore power supply from renewable sources and developing infrastructure to support supply of alternative low-carbon and zero-carbon fuels.

The need to further optimise the logistic chain and its planning, including ports is also identified as a candidate short-term measure, along with the initiation of research and development activities addressing marine propulsion, alternative low-carbon and zero-carbon fuels, and innovative technologies to further enhance the energy efficiency of ships.

In the mid-term, the strategy identifies candidate measures, including an implementation programme for the effective uptake of alternative low-carbon and zero-carbon fuels, including update of national action plans to specifically consider such fuels. In this regard, there may need to be further consideration given as to how to incentivise the uptake of alternative fuels and innovative technologies. As a short-term measure on GHG emission policy, it could be considered to include other studies within the policy decisions, such as updating of Marginal Abatement Cost (MAC) Curves and alternative low-carbon and zero-carbon fuels.

Joint efforts of ICS (International Chamber of Shipping), IMO (International Maritime Organisation) and ICCT (International Council on Clean Transportation) on reduction of GHG emissions study revealed that significant reduction already achieved by the shipping sector since 2008, the meaningful progress with short term GHG reduction measures yet to be achieved by 2023. While these short term measures would be very important, IMO have to move on to developing the long term measures that will truly take the shipping industry towards the complete decarbonisation. (Ref: ICS - Annual Review 2019)

In March 2019, in conjunction with other international ship owners' associations, ICS made an important submission to IMO in order to highlight the fact that, when account is taken of projection for future trade growth, the industry cannot achieve the 2050 GHG reduction targets using fossil fuels alone. This may require an efficiency improvement of around 90% compared to 2008 emission scale, which cannot be delivered with current propulsion systems. If the 2050 target is to be met, commercially viable low emissions ships need to start appearing on market by the2030s. To expect significant reductions in GHG emissions over the next decades, the shipping sector of the maritime industry going to require a serious commitment and massive investments in R&D (Research and Development) of 'nearing zero' CO_2 emitting fuels , propulsion systems and other new technologies.

The new and innovative measures to encourage R&D should be a key component of the long-term measures that were considered by IMO in 2020 and the work on this needs to be completed before 2023.

A comparative study on GHG emission reduction during Third IMO GHG Study and ICCT, there are encouraging results showing reduction in International Shipping Emissions compared to Increase in Global CO_2 Emissions. (**Figure 2**)

The new and innovative measures to encourage R&D should be a key component of the long-term measures that were considered by IMO in 2020 and the work on this needs to be completed before 2023

Global projects support on IMO GHG strategy

Support for implementation of IMO's energy-efficiency measures is provided through major global projects executed by IMO. These include:

The Global Maritime Energy Efficiency Partnerships Project (GloMEEP Project), aimed at supporting the uptake and implementation of energy efficiency measures

Figure-2: Comparative Study of Third IMO GHG and ICCT.
Reduction in International Shipping Emissions to Increase in Global CO_2 Emissions
(Source: ICS Annual Review 2019 - Third IMO GHG Study & ICCT)

for shipping, thereby reducing greenhouse gas emissions from shipping. The GloMEEP project was launched in 2015 in collaboration with the Global Environment Facility and the United Nations Development Programme.

The Global Industry Alliance to Support Low Carbon Shipping (or GIA), launched in 2017 under the auspices of the GloMEEP Project, is identifying and developing solutions that can support overcoming barriers to the uptake of energy efficiency technologies and operational measures in the shipping sector.

The Global Maritime Technology Network (GMN) project, funded by the European Union, has established a network of five Maritime Technology Cooperation Centres (MTCCs) in Africa, Asia, the Caribbean, Latin America and the Pacific. Through collaboration and outreach activities at regional level, the MTCCs will focus their efforts during 2018 and beyond to help countries develop national maritime energy-efficiency policies and measures, promote the uptake of low-carbon technologies and operations in maritime transport and establish voluntary pilot data-collection and reporting systems.

GreenVoyage-2050 project, a collaboration between IMO and the Government of Norway. The project, launched in 2019, will initiate and promote global efforts to demonstrate and test technical solutions for reducing such emissions, as well as enhancing knowledge and information sharing to support the IMO GHG reduction strategy.

Multi-donor trust fund for GHG - MEPC 74 (May 2019) agreed to establish a voluntary multi-donor trust fund ("GHG TC-Trust Fund"), to provide a dedicated source of financial support for technical co-operation and capacity-building activities to support the implementation of the Initial IMO Strategy on reduction of GHG emissions from ships.

Conclusion

Climate change impacts on ports and their hinterland connections and related adaptation requirements are major development challenges with direct implications for trade and growth. While more work is needed to help advance understanding of the various issues at stake in environmental shipping and better assess their full implications, adaptation action in transport generally and, especially, in ports, is an imperative and a sound investment with high returns in the long term.

A comparative study and analysis demonstrate that under the guidelines and statutory framework of IMO with timely compliance by all the stakeholders in maritime industry, the future reductions in emissions would be achieved optimistically within the time frame.

With a few innovative measures in ship operations, increasingly large ships being deployed to the container fleet, loading and unloading containers using ship-to-shore cranes becomes more time consuming and reduces the overall efficiency of the ship-port transaction. As new containerisation concepts are being envisioned that involve either larger containers or container clusters, new or hybrid approaches to loading and unloading containers could improve port transaction efficiency.

One of Wärtsilä future ship scenarios envisions simultaneous overhead crane and rear stern unloading of mega-boxes. In addition to entirely different ships, cargo terminals would have to be completely revised with surfaces designed for much higher weight and back-land (hinterland) infrastructure to conduct intermediate trans-loading or cargo reconfiguration.

Alternative fuels and renewable energy sources are increasingly being used for propulsion and auxiliary power generation. Dual fuel, Electrical propulsion and hybrid power sources such as solar / wind energy are the promising alternatives for moving towards ambitious zero carbon emissions goal envisioned under IMO Strategy.

The traditional "single / twin screw" propeller approach to ship propulsion is by far the simplest and common means of moving a ship, but not necessarily the most efficient or most conducive to maximising efficiency during the ship-port interface. In addition to new hull and propeller designs that enhance efficiency during transit, several technologies that have been common for specialised vessels in the past could be adapted to larger vessels.

Vessel speed reduction/slow steaming, pioneered in 2000, with implementation in the 4th quarter 2001, ship speed reduction (VSR) became a significant voluntary emission reduction measure utilised by many Ports will still continue as an energy efficiency measure. Innovation and best practices for efficient ship operation and ship-to-shore interfacing should be rigorously pursued.

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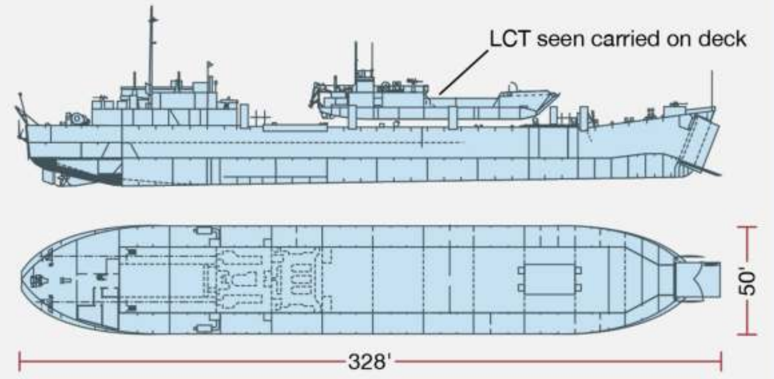
COLUMNS

COMPETENCY CORNER



As-built drawings are drawings that are normally released by the yard along with the newly delivered vessels which specify and conform as to 'Actual Situation or Condition' of machinery installed on-board in 'as is where in condition'

Narayana Prakash

The Importance of 'As-built Drawings'

As-built drawings are drawings that are normally released by the yard along with the newly delivered vessels which specify and conform as to 'Actual Situation or Condition' of machinery installed on-board in 'as is where in condition'. These drawings remain on board till the vessel is finally scrapped.

Drawings finished with higher level of unreliability are shortening design phase but could result with major repair and rework activities that could increase production time and cost.

As-built renderings should detail the shape, dimensions, and precise locations of any and all elements within the scope of the project. Any modifications, whether minor or major, should be included, along with a record of approvals to go along with the changes.

Development

The development of as-built drawings starts with plan approvals from owners and classification societies **(Figure 1)**. All comments are incorporated in the basic drawings and yard acceptance is solely on the basis of the specification and the inclusion as per Class rules. While construction is in progress, changes can be made in production drawings or detailed design drawings and all these changes to be incorporated in as-built drawings with a column in 'Plan History'.

The owners on their part, normally concerning operations are incorporated in drawings. In most cases the acceptance by yard is always in good co-operation as it must not amount to increase in the yards building costs.

3D Modelling

Earlier ships were built at site and all discussions based on the findings at site were taken into considerations and implemented. Today in order to avoid delays and delays due to extra work, 3D modelling sessions are conducted between yard and Owners' representatives during kick-off meetings. 99% of the issues are sorted out as the preferred routing of pipelines is discussed and modifications are made mutually without affecting original design. Any fouling of the Equipment or its associated piping is taken care of at the incipient stage.

Improvements: Performance Vs Efficiency

Improvement is always for betterment (basis operational efficacy), but the gain factors must be permanent and not for a particular situation or period.

The ship staff, especially Engineers resort to make improvement of their choice, hoping that it would serve a satisfied purpose for the gen-next who carry on with the legacy of smooth operations.

It is a general practice that attending superintendents go by the 'as-built drawings' to enquire what went wrong in the process of operation and results. In reality, the modifications are not known to them until ship staff discloses and revises them as built drawings.

Cases have emerged that a batch of engineers during their tenure, made modifications to suit their operational convenience and left the vessel on completion of contract and there is no evidence left on board as to what was carried out on those as-built drawings. If any modifications

"Minor modifications are often made, which usually will deviate from the original Yard or Makers' design but these must be endorsed by the Chief Engineer in the as-built drawing with a revision, after taking approval from the company"

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are made they must be approved by Class 'in principle'. Minor modifications are often made, which usually will deviate from the original Yard or Makers' design but these must be endorsed by the Chief Engineer in the as-built drawing with a revision, after taking approval from the company.

An example is the case of introduction of a small filter in the suction line of LT cooler, on the Sea water side to collect debris and to avoid frequent clogging of the coolers. The cooler's design factor is disturbed by the pressure difference due to flow that was originally designed for. Superintendents depend on the design data related to as-built drawings and for verifications of performance and efficacy.

The records of tests and performance, carried out during sea trials or mooring trials will not be valid anymore and performance needs to be re-tested re-carried out and established as a part of documentary evidence.

It is to be noted that the changes for improvement reduces efficiency from original design due to inclusion in modifications since the purpose for modifications were for operations rather than efficiency

Any such modifications must be sent to yard's design team to assess and calculate their performance standards to the originally designed values. These as-built drawings must be kept on record on-board ships, with revisions, approved by office, termed 'FINAL AS-BUILT'.

It is to be noted that the changes for improvement reduces efficiency from original design due to inclusion in modifications since the purpose for modifications were for operations rather than efficiency. There must be a balance between Performance and Efficiency.

Missed Out Changes

All vessels are built as per specifications but during plan approval stages, the vessel's operations part are ignored or missed out. The drawings are subjected to design, based on basic drawings. At the Hull structural design stages, preferred routings of piping are not taken into consideration. Only during the supervision stage (while under construction), it will become obvious that the requirement is mandatory, (basis for smooth operation of the ships). Hence engineers find it difficult to operate the vessel.

The option left is to live with the problem or to carry out modifications on board or during dry-dock. The Owners having invested a lot during the contract signing stage do not wish to add any further extra costs, unless extremely necessary.

One such case observed in a Chinese yard built vessel was where a void space had number of pipes and piping (bunker pipes and piping) with several valve handling arrangements. The void space had no permanent means for free movement of shipboard personnel for carrying out daily tasks / operation of handling valves. The arrangement provided was a manhole of size 800 mm by 600 mm, which has to be removed every now and then for the purpose of handling operation. It was therefore decided to have a watertight door in the bulkhead. The above job could not be done by ship staff since several pipes outside the bulkhead needed to be rearranged. Also lighting and ventilations were to be provided in the space. This is an example of a design in which the operational difficulties were not thought of.

Sometimes it takes even 15 years of operation to understand what went wrong in design affecting smooth operation/maintenance of the vessel.

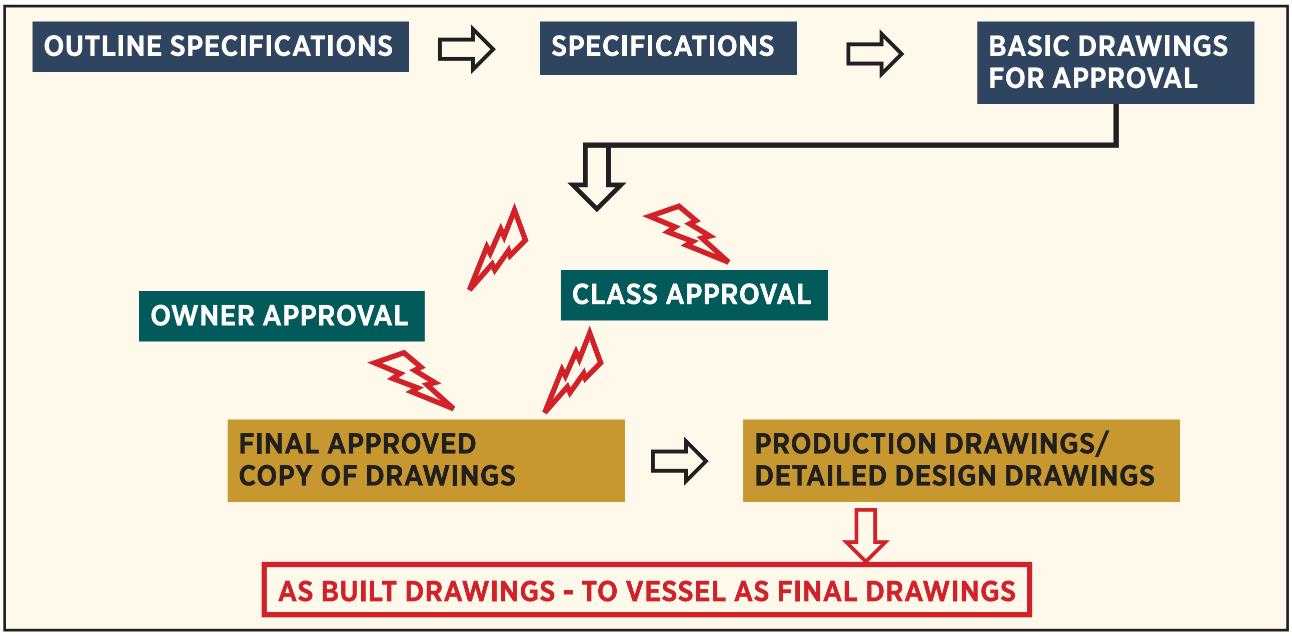
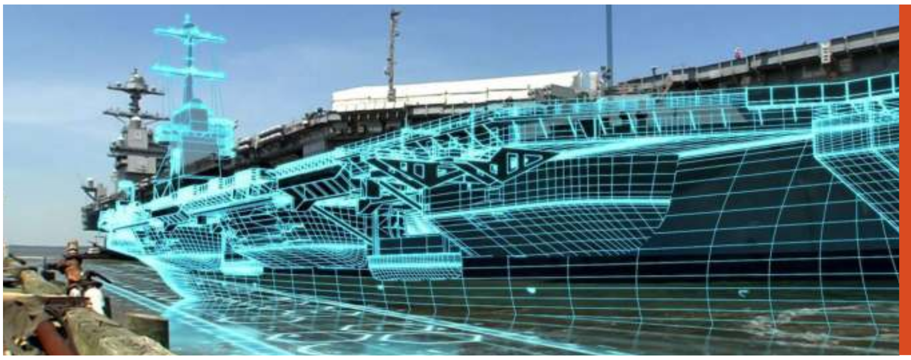


Figure 1: Process of finalising 'As-Built' Drawings



Sometimes it takes even 15 years of operation to understand what went wrong in design affecting smooth operation/maintenance of the vessel

A vessel was found to have no isolation valve in the ME jacket outlet and for carrying out decarbonisation of a particular unit, and entire engine water had to be drained. In such cases, engine makers must be given feedback as a part of improvement programme regularly by the ship-owners. Engine makers, MAN B&W and Wärtsilä have been regularly participating in such feedback programmes and improvising continually.

During the new building stages, it is preferable to attend the shop tests of all important equipment (at factory) to sort out issues relating to future maintenance. If any point is still missed out, the same can be brought out to Yard or Makers' notice while on-board tests are being conducted.

Temporary Modifications Vs Permanent Modifications:

Whereas Temporary modifications to tide over crisis on-board must be made for the time being and must be reverted to original plans as per as-built drawings. There are cases observed that a batch of Engineers made modifications and left it as it is without thinking of the repercussions.

One example is that of an Emergency fire pump not taking suction, even with a sea water priming line made on the suction side of the pump. As a step to enhance priming, engineers made a fresh water connection from the Fresh water hydrophore outlet, which they thought would aid in improving suction with application of a pressure head. This modification was never discussed with office nor any revised as built drawings made. On one occasion when Emergency fire pump did not take suction, this newly fabricated fresh water valve was left open, only to lose 20 MT of fresh water in 12 hours. Does such type of modifications help in long run?

This is both ignorance and non-conformance to reporting to office, and also with no changes made in as built drawings or providing information stating what precautions need to be exercised.

A word of caution in the retrofit jobs: Always check for fouling of existing pipelines that needs to be removed for future renewal in case of corrosion and damage

Structural drawings

The structural drawings that need to be indicated with renewal thickness (if submitted at the time of class approval) are as follows (MSC Circ/1135).

Key structural drawings include:

- Typical Mid-ship section
- Construction profiles/plans and deck plans
- Shell expansion
- Cargo tank construction plans
- Typical oil-tight, watertight and non-tight transverse bulkheads
- Fore End and Aft End construction plans
- Engine Room construction plans

Renewal thickness is to be marked for:

- All plating members
- All primary and local supporting members including face plates

As-built thickness (t-as built), corrosion addition (t-corr) and renewal thickness (t-ren) for all structural members must be checked in case of vessels more than 15 years old.

Vessels built before year 2005 do not usually mention renewable thickness in structural drawings and hence Class needs to be consulted if after thickness gauging, material loss is more than acceptable.

If any plate renewal takes place, grade and scantlings are to be referred to as per original approved drawings.

Unanswered Question: Why should we trace, correct, inform and record?

On-board any ship you will find some abnormalities. When modifications are made without any notifications, abnormalities are noticed. A case of LO drain Tank filling up abnormally was noticed. While the as-built drawings were checked, all is well but in fact some tray drains were inadvertently connected to LO drain tank which was filling up quickly.

Accounting for Modifications made in 'Company Software'

Inclusion of permanent changes by Ship staff has to be done in Vessel's software system. The modifications made in 'as- built' drawings with revision are to be included so that it will be known to all Engineers who will come by. Also a performance report after modifications has to be updated in the system.

The as-built aspect has to be covered in the internal audit checklists etc., with questions such as:

Are the as built drawings of the bilge and sludge transfer and management available on board and reflect actual arrangement?

Since above query is related to Marpol, implications are on highest level. Similarly, any Modifications on any systems on board must be Verified- Approved- Entered in the Company's software system.

Taking over vessels

While a batch of joiners who board the vessel for takeover is dependent on the handing over documents. In some cases, the sign-off crew just disembarks, with no handing over notes. Several issues, including the as built drawings and the actual layouts come in to focus here.

It would be prudent if the takeover staff, requests for modifications in as-built drawings which will make the takeover easier. The last option is to verify the pipes and fittings with the drawings provided and as-built drawings may be updated on-board by the joining staff.

If any modifications are found, the same can be removed/ reverted back to as in the original as-built drawings.

Additions of Newly Installed Equipment

It has been observed that sometimes new equipment like BWTS or Scrubber Plant or RO plant is installed on board in an existing ship and there are no updated as-built drawings which include these. Even if as-built drawings are present, the interconnections with existing pipelines or equipment is not dealt with at all in proper way. Furthermore, certain modifications to existing pipelines/ installations, to be shown in final approved drawings in the order of 'preferred routings' by designers are also missed out.

Conclusion:

This article highlights an operational challenge faced by seagoing engineers during construction and after construction, keeping in mind that all modifications are to be carried out only after securing approvals.

As mentioned, as-built drawings should chronicle any changes made from the original design during the construction process or while the ship is in operation. These changes should be explained clearly in writing, along with the date on which the change was made. Any deviation from the original plan should be specified, whether the change was in design, location, materials used, or all of the above.

About the Author

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SMART SAFETY HELMETS

Amit Vaishnav, Nikita Sachan
B.Sc. (Nautical Science), Second Year

Abstract

This paper aims at presenting a possible idea for enhancing the safety culture that has always been an important aspect at maritime industry. This helmet can help the mariners to detect all the possible red signals on board. Red signals which includes, man overboard and any kind of health issues on board. The authors here have tried using the evolving modern technologies to contribute towards the safety measures of the industry. The author here has tried bring up the prototype with required research which can be helpful by every means and can also help in increasing the safety measures which are already been taken care of. A proper attention towards the whole safety related research can help the author in enhancing the scenario.

Keywords : Technological innovation, safety culture, man overboard

Introduction

Safety in maritime industry holds paramount interest and is of utmost importance, majority of the accidents happen due to the intentional/unintentional carelessness of the crew members, improper monitoring or insufficient information about the situation are the contributing factors. This paper aims to reduce many such risks on board by making use of a smart safety helmet that could effectively monitor and send alarms to alert the bridge of untoward incidence to enhance safety. This paper comprises of the details of such a prototype developed by the author.

Purpose

Preventing Carelessness among mariners and hence drastically reducing accidents on board.

Idea

According to safety precautions on board the ship, a person working on deck is supposed to wear a safety helmet at all the times. Hence, adding smart features to the helmet would solve the monitoring and alarm raising problems on board ship. The embedded sensors would trigger the alarm on the bridge which is always manned. The helmet would be connected to the monitoring unit through Wi-Fi direct. Since each unit will have an assigned identity code every individual would be identifiable when on deck.

Any error or message received from the helmet will be displayed here along with the crew members name and this will activate the desired buzzers and alarms to draw the attention of the Officer-on-watch.

Usage as a safety helmet:

- on board a ship
- dock labours
- dry docking and repairs of the ship

Components used:

- A Safety helmet
- Microcontroller Unit with Wi-Fi
- Alcohol and Gas sensors
- Pulse sensor
- Accelerometer sensor
- Water sensor
- Li-Po battery (9 V)

Functions Served by the prototype:

- Detecting man overboard situation
- Alcohol detection
- Toxic gases detection
- Pulse rate monitoring

- Sending all this data to the bridge display using a node MCU or WIFI Direct module.

Alcohol/Toxic gas Sensor

Alcohol sensors can measure as low as 0.04 mg/l alcohol presence. It would be able to sense from the breath of the crew member. If the person is found drunk, the helmet will send a message to the bridge and the LED on helmet will glow along with the buzzer sound to alert the bridge and other personnel in the vicinity. This will be able to reduce the accidents caused by drunken crew members and hence in compliance to the no drinking policy of the shipping companies.

The Analog Output pin (AOUT) gives Analog Voltage Output in direct ratio to the amount of alcohol detected by the sensor which then triggers the Digital Output(high/low) based on the values received though the analogue output. The Higher the amount of alcohol in a person's breathe, the higher will be its analogue output and vice versa [1]. Once the Analog Value crosses its set threshold limit, the digital output is triggered 'high' and the sensor will next activate the buzzer on the bridge and on the helmet as a warning signal.

The Toxic Gas sensors can detect gases like Ammonia, Benzene, Methane, Hexane, LPG and Carbon Monoxide, thus giving an early warning to the person wearing it along with alerting the bridge. For the demonstration of concept, MQ3 and MQ135 sensors were used. There are sensors capable of detecting as low as 20 ppm of alcohol. Thus a system with fool proof detection of alcohol is viable.

The Alcohol and Toxic Gas sensors housed close to Mouth

- **Pulse Sensor**

The second sensor would be a pulse sensor to read the pulse of the person wearing the helmet. The LED on the front side of the sensor is to be placed on a vein (here the ear tips). Veins have blood flow inside them only when the heart is pumping, thus the pulse sensor monitors this blood flow to monitor the heartbeat. According to the data received by this sensor, various aspects about a person's health in general could be calculated like sleep tracking, anxiety, and consciousness [2]

Benefits:

- It would confirm if the crew is **wearing a helmet** since it starts getting the pulse input from the nerves near our ears/from the smart watch and hence ensure compliance of safety regulations.
- If it finds the pulse rate of the person is too low or too high, during enclosed space operations, it will alert the officer (both him and the watch keeping officer on bridge) of his **abnormal health**. If it fails, then it will direct the ESP8266 WIFI module on the helmet to send a message to the bridge indicating his retarding wellness during the operation and needs immediate rescue.
- This will then combine the data from the toxic fumes sensor so as to **warn the incoming rescue party** about the atmosphere in the enclosed space.

Accelerometer Sensor

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static (gravitational) or dynamic - caused by moving or vibrating the accelerometer. [3] These forces can be detected based on Axis-wise rotations. So, we try to set a parameter that after a specific Rotation (i.e. how much does the person receives an impact after falling in an accident) it will detect an accident.

The basic work of the accelerometer in the helmet is to detect a fall i.e. it calculates a fall based on the acceleration in all the three directions- x, y and z axis.

Once fall is detected either by free fall due to gravity method in the accelerometer or by change in the angle of the helmet method it sends out this data to the bridge alarming the officer on watch to take adequate actions immediately. The prototype has been adequately programmed to detect such cases (e.g. Man overboard) using the free fall and direction angle algorithm.

There have been a lot of cases where the person has become overboard and no one was able to detect this for hours resulting in never finding the person again, or maybe finding him dead because of drowning in the sea or animal attacks. Using the helmet, this can be easily countered as the detection will be done as soon as the man falls overboard and hence the crew members will have enough time to take proper and effective actions.

The helmet will also have an **additional water sensor** so as to accurately detect that it is a case of man overboard. Considering the situation where maybe by some error the buzzer goes on or where the crew member has fallen on the deck and is in no danger

Change in the angle of the helmet method it sends out this data to the bridge alarming the officer on watch to take adequate actions immediately

i.e. the fall isn't crucial then he will have a **kill switch mechanism** on the helmet to **kill the buzzer alarm to prevent misinformation**.

COST-EFFECTIVENESS:

The current prototype cost sheet is:

	Material used	Cost(INR)
1.	Arduino Uno	400
2.	Alcohol and gas sensor	160
3.	Accelerometer sensor	260
4.	Pulse senor	355
5.	DC jack wire	08
6.	LED lights and buzzer	15
7.	Wi-Fi MCU	190
8.	Node MCU	270
9.	12 volt battery	15
10.	A normal safety helmet	100
	Total	1773

Production Development Requirements. The Prototype was fabricated using components locally procured. It is possible to engineer the entire circuit as a single hermetically sealed module and shaped it to sit within the helmet without interfering with its basic safety function. The cost of system could be lowered substantially when produced on economic scales. Also sensors with lower detection threshold can be incorporated at marginally higher cost.

Sensors activation in a sequence: -

1. Person wears the helmet
2. alcohol check, if negative continue
3. pulse rate monitoring on
4. toxic gas monitoring on
5. accelerometer active throughout to detect fall
6. water sensor backup for accelerometer

Accident detection and related actions: -

1. fall detected; sound bridge alarm
2. man overboard alarm and lights activated
3. pulse rate error or toxic gas detection
4. activate bridge alarm and call rescue team
5. false alarm sounded due to error
6. person uses the kill switch on helmet to kill alarm

EXPECTED LOOK OF THE FINAL PRODUCT:

Features of this design

- Effective placing of all sensors
- Waterproof casing for battery and board
- Kill switch on the sides
- LEDS and buzzers inbuilt with no additional changes to the effective strength of the helmet
- Modified design to also accommodate the **face shield/ mask**

SUMMARY

Reducing the chances of accidents and taking effective actions without wasting precious time is essential way of preventing damage to life and property at sea. This paper thus explores the idea of using an advanced helmet that could cater to modern needs on board. It comprises of various sensors which collect real time data of the crew member and alert others on- board as soon as any unfavourable situation comes up. This paper has outlined the major advancements that are possible in a safety helmet and has tried to promote a safe work environment through innovative ideas by making the right use of currently available technology.

[This paper was adjudged third in the INSA (Indian National Shipowner's Association) Technical Paper Competition held on-line on 20 February 2021]

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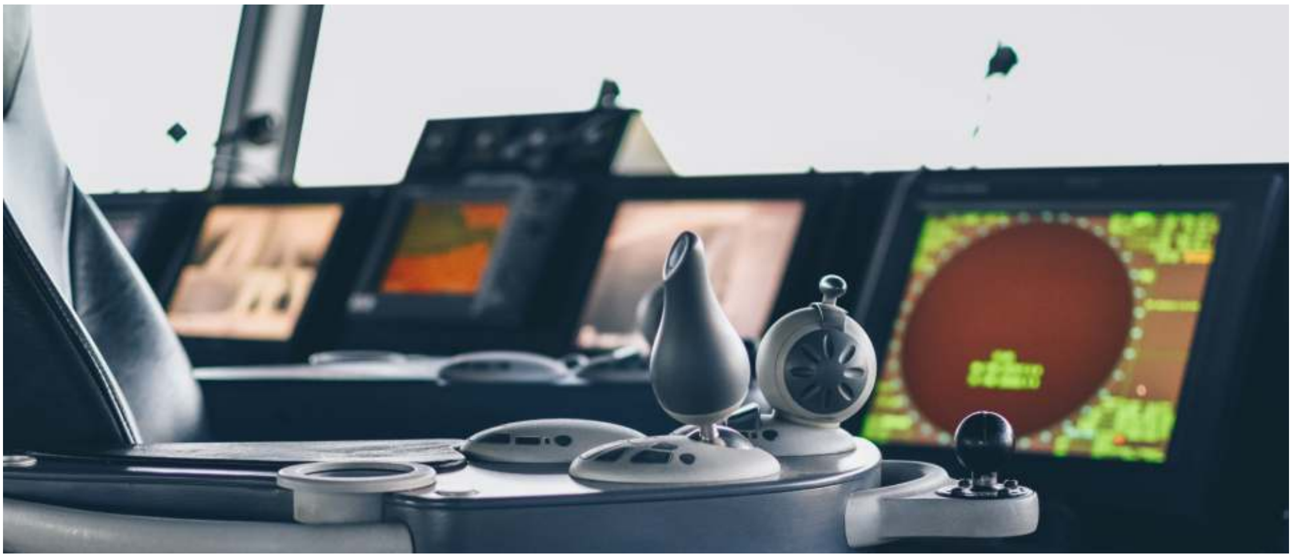
LUBE MATTERS 3: ELEMENTAL ANALYSIS



Sanjiv Wazir

Introduction

One of the most effective ways of detecting potential machine failures prior to them becoming too expensive and serious, is by measuring wear metals in lubricating and engine oils. Often, these elements can also help to identify the failing component. Besides wear elements, measured elements include additive elements, and elements from fuel and external contaminants. Some elements can have multiple sources.

Spectroscopy

Spectrometry is the main technique used for detection of wear, and its severity. Since every element is characterised by a unique atomic structure, the addition of energy causes each element to release light of specific wavelength (or colour). The difference between the spectral lines of different elements helps to distinguish them from each other. The intensity of the light emitted varies in proportion to the amount of element that exists in the sample, enabling the determination of its concentration.

There are different methods of adding the energy to the elements, such as Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma Spectroscopy (ICP), Rotating Disc Electrode Spectroscopy (RDE), X-Ray Florescence Spectroscopy (XRF), etc. Each has its strengths & weaknesses.

ICP is the most used method. It is accurate and gives high repeatability. But it requires trained technicians and lots of clean argon gas, automation, maintenance. It is well suited for high-throughput labs. A stream of argon gas is ionized at high temperature, a small amount of diluted sample fluid is injected into the plasma through a nebuliser and the spectral emission is recorded, measured, and analysed. However, particles larger than 5 - 7 microns are not well detected by this method as they are not fully vaporised in the plasma due to mass effects and so wear element concentration can be underestimated in cases of high wear. Additional processes (e.g., acid digestion) may be required for such samples.

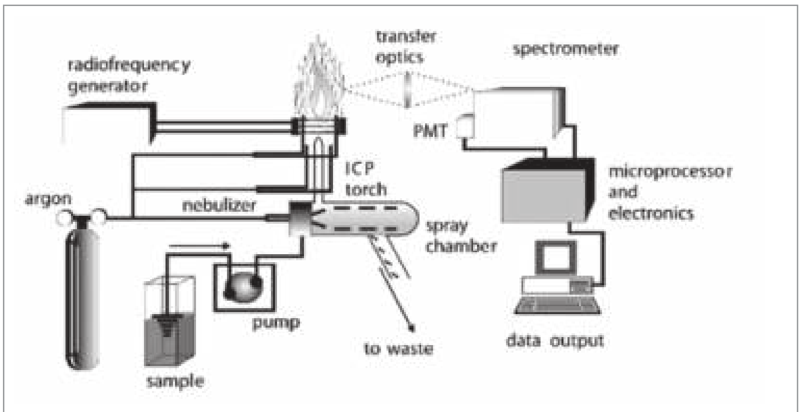


Figure 1 Inductively Coupled Plasma Spectroscopy (Ref.2)

It must be noted that depending on the type of test equipment and sample preparation, the results obtained can be quite different. When comparing or plotting results for trend analysis, ideally one should be comparing data from the same laboratory, the same apparatus, and the same method. Also, the accuracy and detection limits of the methods should be considered. Low values (below 5 ppm) should be interpreted with caution.

Various ASTM standards for spectroscopy cover different sets of elements & number of elements. LUKOIL Marine carries out elemental analysis as per ASTM D5185-18

A TO Z OF SPECTROCHEMICAL ELEMENTS

Detected element	Possible sources				
	Lubricant	Contaminant	Engine	Hydraulic system	Others
Aluminum **(Al)**	Grease thickener	Cat-Fines, Dirt & Dust	Pistons, Bearings, Bushings, Shims Head Block, Cylinder Block	Pump/Motor housings, Cylinder glands	Air Comp Pistons, Blowers, Rotors, Thrust bearings, Turbocharger bearings, Impellers, Clutches, Coolers
Antimony **(Sb)**	Grease additive		Bearings(overlay)		
Barium **(Ba)**	Additive, Grease Thickener				
Boron **(B)**	Limited EP Additive, Grease	Water inhibitor, Coolant (borate)			
Cadmium **(Cd)**			Bearings		Plating's
Calcium **(Ca)**	Detergent Additive, Grease Thickener	"Hard" Water, Dirt			Airborne contaminant
Chlorine **(Cl)**	AW & EP Additive	Sea water			Sea water
Chromium **(Cr)**		Chromate corrosion inhibitor from coolants	Cylinder liners, Rings, Crankshafts Some Roller Bearings, Exhaust Valves	Bearings cages, shafts	Bearings, Valve Spools, Some plating materials
Cobalt **(Co)**			Some Roller Bearings	Some Bearings	Turbine components
Copper **(Cu)**		Anti-seize compound	Bearings, Bushings (wrist pins), Oil Cooler, Radiators, Camshafts, Clutches, Valve guides,	Pump pistons & thrust plates, Coolers, Cylinder glands	Heat Exchangers, Bearings, Bushings, thrust washers, Brass (in conjunction with Zn), Bronze (in conjunction with Tin), Discs, Wear plates, Sealants & Gaskets
Indium **(In)**			Bearing overlay		Solder
Iron **(Fe)**		Rust	Cylinders, Blocks, Gears, Crankshaft, Rings, Camshaft, Cams, Valve train Bearings, Pumps	Pumps/Motors housings, vanes, gears, pistons, Rods, Valves	Gears, Shafts, Housings, Fasteners, Crankshafts, Shafts, Rods, Rings, Bearings Thrust washers
Lead **(Pb)**	Additive	Paint	Bearings, Bushings, overlay	Seals	Solder, Anti-seize, Petrol/ gasoline additive
Magnesium **(Mg)**	Detergent Additive	Sea water	Component Housing, Some Al alloy parts		Aluminum alloy parts
Manganese **(Mn)**	Additive		Valves, Blowers, Exhaust & intake Valves		Alloy parts (unleaded) Petrol/ Gasoline additive
Molybdenum **(Mo)**	AW Additives, Friction modifiers		Piston Ring overlay, liners		Anti-Cavitation inhibitor
Nickel **(Ni)**		Crude oil constituent carried over in Residual Fuels	Bearing metals, valve stems/guides, ring inserts on pistons, turbo charger blades		Stainless Steel components, High Strength Steels, Gears
Phosphorus **(P)**	AW & EP Additives	Coolants			pH buffer
Potassium **(K)**		coolants			pH buffer
Silicon **(Si)**	Anti-foam Additive	Cat-fines, Sand, Airborne dust, Anti-freeze		Seals	Transmission Disc Linings

Detected element	Possible sources				
	Lubricant	**Contaminant**	**Engine**	**Hydraulic system**	**Others**
Silver **(Ag)**			Some Engine Bearings (e.g., EMD engines)		Bearing Cages, Solder
Sodium **(Na)**	Additives, Grease Thickener	Sea water, Coolant, Dirt, Crude oil constituent carried over in Residual Fuels			Anti-Freeze, Sea water contamination in fuel
Sulphur **(S)**	AW & EP Additive	Crude oil constituent carried over in Fuel			
Tin **(Sn)**			Piston overlay, Rings Bearing overlay, Bushing's wrist & pins	Seals	Solders, Bearing overlay, Bronze & White metal alloy component
Titanium **(Ti)**		Paint	Springs		(Gas) Turbine components
Vanadium **(V)**		Crude oil constituent carried over in Residual Fuels	Turbine impeller blades, Valves		Turbine components, Surface coatings
Zinc **(Zn)**	AW additive, Corr. & Oxid. inhibitors		Component of brass alloys		Galvanized metals & plating's, Component of brass alloys

Particulate Quantifier (PQ)

PQ Index is the measurement of the total ferro-magnetic metal content in oil. Particle Quantifier exposes a lubricant sample to a magnetic field and the presence of ferrous metals creates a distortion in the magnetic field. If the PQ index is high, the ferro-magnetic metal content in the sample is high and abnormal (Abrasive/Adhesive) wear is likely taking place.

Figure 2 Particulate Quantifier (Ref. 3)

Generally, wear under aggressive tribological condition such as abrasion & adhesion tends towards producing wear debris over a wide range of sizes. As a result, spectroscopy which only captures data from particles typically less than 5-7 µm in size, may tend to plateau or even reduce over time, while PQ value is rising.

Thus, PQ is good adjunct to spectrometry. Trends of PQ and Fe (measured by spectrometry) allows better interpretation of the kind and severity of the wear taking place. LUKOIL carries out PQ test on most samples where spectrometry is carried out.

References:

1. Used Engine Oil Analysis-User Interpretation Guide, CIMAC No. 30/2011
2. A Guide to Spectroscopy for used Oil Analysis, Amtek Spectro Scientific, 06/2016
3. Parker Kittiwake Analex Brochure
4. Oil Analysis User Guide, Agat Labs Ltd.

About the Author

Sanjiv Wazir is a Technical Adviser with LUKOIL Marine Lubricants. He is a mechanical engineer from IIT-Bombay. He is a marine engineer and a member of the Institute of Marine Engineers. He is a Certified Lubrication Specialist from the Society of Tribologists & Lubrication Engineers (STLE), USA and is a member of the Tribological Society of India. He has contributed to MER on marine lubrication developments in the past, and on oil contamination issues under "Lube Matters", earlier.

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MARINE ENGINEERS REVIEW (INDIA)
LUBE MATTERS 2
WHAT MY UOA RESULTS ARE TELLING ME
Sanjiv Wazir

Corrigenda: MER August 2021 Issue

Lube Matters 2; Page 48

1. Column 1; left/bottom; (ASTM D445-18); Table Title should read: **VISCOSITY INCREASE**
2. Column 2; centre/middle; 4th Table from top (ASTM D2896-15 Procedure B); Missing Table Title: **INCREASE IN BN**

COLUMNS

INDICATOR CARDS

This forum is for reflections from readers.

Do mention your name, email, membership grade and number (if Member of IMEI) with your mails.

Dr. Surendar Kumar

The future of Education, Training and Assessment

It is a well-known fact that we humans have been predicting future from time immemorial. Social media is gaining edge the way we teach and learn. This resulted in distance learning and asynchronous learning becoming more acceptable and popular.

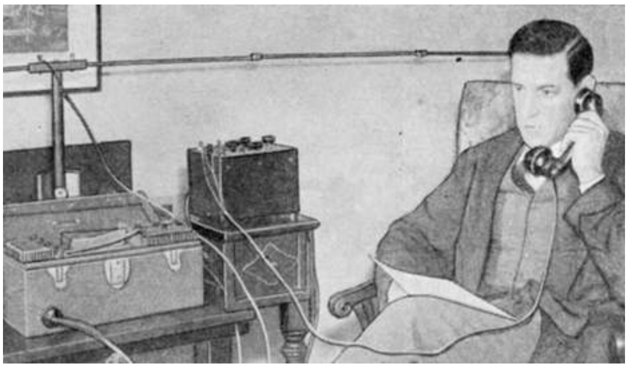
Technology in training & assessment

The education system of the past was easily recognised by delivery of lectures using chalk and board. Research in any field was time consuming as compared to existing conditions today. Looking back into the past of the educational technology, one can easily recollect the words of Thomas Alva Edison "The motion picture is destined to revolutionise our educational system and...in a few years it will supplant largely, if not entirely, the use of textbooks."

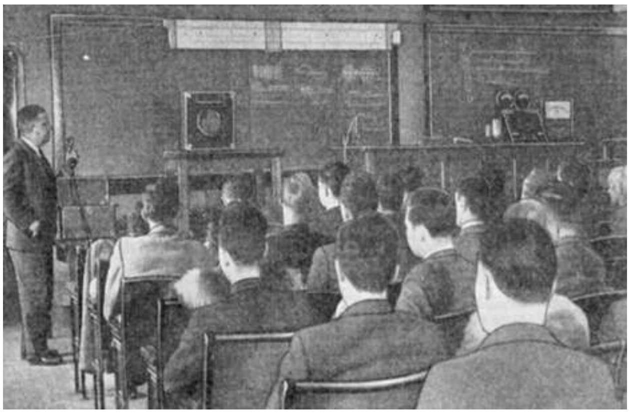
In the Short Wave Craft magazine, (April 1935 issue), the scene of introduction of television based learning was explained as follows: "The scene will be a commonplace one tomorrow, without a doubt, when television will be as indispensable to our everyday home life as the radio program receiver is today."

The pictures clicked way back in 1935, speak volumes.

In 1954, famous Harvard professor, BF Skinner, described the "New Teaching Machine" which can be the nearest the modern day online learning. The new teaching machine had the following benefits which were unique then.



A teacher on a television class (Source: Google)



Remote learning way back in 1935 (Source: Google)

- Self-paced learning
- Immediate feedback
- Capable of aligning learning with the level of students' capabilities
- Less time consuming as compared to conventional training/education

Prof. B.F. Skinner with his New Teaching Machine (Source: Google websites)

Our own platform for active learning SWAYAM which stand for Study Webs of Active–Learning for Young Aspiring Minds is a programme started by Government of India. This platform is designed to achieve the three cardinal principles of our new education policy i.e. access, equity and quality.

National Programme on Technology Enhanced Learning (NPTEL) which is a project of MHRD, is a big initiative and is the combined efforts by seven Indian Institutes of Technology (Bombay, Delhi, Kanpur, Kharagpur, Madras, Guwahati and Roorkee) along with the Indian Institute of Science, Bangalore. All these institutes of repute got together and in 2003 and they pledged to provide quality education to anyone interested in learning from the IITs using available technological tools.

NPTEL of SWAYAM is the largest online repository in the world of courses in engineering, basic sciences, and selected humanities and social sciences subjects.

More often the future of education is viewed through the lens of dawning and emerging technologies. Big data, artificial intelligence (AI), virtual reality (VR), augmented reality (AR), machine learning (ML), deep learning (DL), coding, learning analytics (LA) and robots will be continuous source of upgrading the learning experiences in the near future.

The future of assessment

The assessment may be formative or summative or an appropriate mix and the following methods may be used:

- Web-based assessment (Quizlet, Kahoot, Socrative, and many more)
- Technology enhanced classroom assessment: It is formative assessment strategy that is learner-centred, teacher-directed. **Chain notes, misperception/ preconception testing, word journal and muddiest point are some of the prominent methods.**
- Diagnostic assessment may be used to check the current level of knowledge and skill of a learner.
- Goodness of measurement: reliability, validity, objectivity
- Modern Test Theory and adaptive testing
- Modern technology and assessment: Game-based, Simulation-based assessment

The below mentioned are some of the more often used formative assessments tools in the virtual classroom:

- Dipsticks
- Elevator pitches and tweets
- Digital journals and one-pagers
- Peer-to-peer evaluations
- Virtual exit tickets
- Make art your assessment
- Square, triangle, circle

The above mentioned methods are only indicative.

The Future

New technology will continue to influence the education and training of the future. Lower costs associated with the new online technology based learning and teaching will attract more investments and better talents to make significant contributions in the future.

It will be ideal to conclude with David Warlick's words "For the first time we are preparing students for a future, which we cannot clearly describe". This can be really challenging for the teachers!!

About the author

Dr. Surendar Kumar (CEng, CMarEng, CMarTech, FIMarEST, FNI, Ph.D) is Ex-Principal of Bibby/VShips training centres, a DP Trainer and a Faculty teaching MBA/PhD students in many Universities. He is also attached as Visiting Faculty of Korea Maritime and Oceans University, Busan. He has seven research papers to his credit published in refereed national/ international journals and two books on dynamic positioning.

MET ON-LINE DELIVERY: CHALLENGES DURING THE PANDEMIC

In the current MET formats, the online deliveries have become a norm.

Challenges For The Faculty

'Chalk and Talk' was the most preferred mode of teaching, in combination with PPT and short videos to supplement and drive home the theory concepts. Faculty and candidates had direct interaction to clarify doubts.

Accepting the On-line classes

The major challenge for the Faculty was in accepting the change of delivery mode in the first place. If this pandemic would not have happened, most of the people does not able to think about online classes.

There are still a few, very experienced Faculty, who feel on-line mode is not suited for Maritime training. But the need of the hour demands that we adapt to this mode.

Accepting the Technology

The next major challenge for the Faculty taking on-line classes is adapting to the latest Educational Technology [Ed-Tech]. Most of faculty are well versed with basic computer skills learnt over their professional career. These basic computer skills are enough to start online classes.

Internet bandwidth

On-line classes require a fairly good internet bandwidth to have an uninterrupted / lag free experience.

Missing Chalk (marker pen) and Board

On-line whiteboards, Electronic Drawing Tablets linked to the computer etc., are tools readily available. These come handy and can handle most, if not all the drawings or free hand sketch needed for On-line classes.

Lack of sufficient materials for On-line classes

With MTIs shut, the library facilities have become inaccessible to Faculty and students. Here e-books and publications come to our rescue.

Keeping the attention of candidates

Giving real life scenarios, using case studies, asking right questions which make the candidates think

To Mentor or Not

Why Mentoring at Sea is vital?

Imagine some asking you 'Are you a mentor?' It is quite likely you would say 'No.'

Mentoring is usually set out as a formal process and often on a designated one-to-one basis over a fairly long period of time.

In fact, there are many people who take great pride in having a mentor and they believe they are very lucky to have someone as a mentor for much of their career. Why should a shipping company give emphasis to mentoring?

- To develop leadership or talent pool as part of succession planning;
- To work on diverse issues that hinder their success;
- To help its staff in ways that are additional to the acquisition of specific skills/competencies;
- To retain its internal expertise and experience on shipping related issues residing in its baby boomer employees for future generations;
- To create a workforce that balances the professional and the personal side well;
- To make the Mentees perform better.

Necessary tools for mentors

Unlike on board training, which demands time resource, mentoring is an informal process and takes place better while being engaged in shipboard operations.

However, there are many challenges and roadblocks, which are mental and emotional. In order for mentoring to succeed, language and cultural barriers must be transcended.

In order to further help in a successful mentoring, there are three tools that every mentor must certainly add into their to-do list. These are:

1. Reflection: Reflection is a very important tool and seriously underrated in these days of excessive chatter on blogs, Twitter, Facebook and such social media.
2. Reverse mentoring: Reverse mentoring is another gem that challenges the idea that someone must be a senior pro in order to qualify as a mentor.
3. Relevance: Relevance is another critical tool. We are attached to things that were easy and common during our time, mentors must understand that youngsters will quickly sense that they have not bothered to update their old skills and knowledge over time.

Seven tips for a successful mentorship

1. Clarify expectations
2. Confirm the logistics
3. Help the mentor to help you
4. Don't ask for too much too soon
5. Have a plan for when things go south
6. Give back
7. Have fun

(Source: Nautical Institute; November 2020; in Maritime Knowledge).

L. S. Ganapathy
Email: ganapathyls@gmail.com

and reply, application of concepts to real life, exams oriented discussions etc., can gain better attention of the candidate.

Explaining Numerical Exercises (especially technical matters)

Faculty can make a PPT of the numerical and project it to the class or use on-line white board / electronic marking tablet to solve the questions live in the class.

Sticking to time limit as per Lesson Plan

Topics can be covered in on-line classes in shorter time frame as compared to physical classes.. Mini Assessment, Multiple Choice Questions (MCQ) tests, assignments etc., can be used to gauge the understanding of the candidates.

Disconnect between Theory and Practical classes

Another major challenge faced by the Faculty is the disconnect between Theory and Practical classes.

In order to avoid this break of continuity, trainers are encouraged to make videos of practical elements and show them in the class.

Threat of Intellectual Property of Faculty

With On-line classes, there is a threat of the PPT getting copied and used by someone else.

Faculty and MTI can put distinct watermarks to ensure they get indirect credit when materials are shared around.

Efficacy of On-line Assessments

The major challenge of existing On-line assessments is the limitation of (single - in the face - device) the camera.

One way to circumvent this is to tweak the questions asked in the on-line exams. Time limited MCQs with random questions, randomized choices are also helpful.

Strain of staring at Computer monitor screens

Faculty need to take care of their health and eyesight when involved in long hours of On-line classes. They should have correct light and screens; they should take small breaks to avoid strain during the classes.

The Norm of Working from Home

Work from Home, or "Teach from Home" in the case of a Faculty is supposed to be best of both worlds.

Ideally a separate quiet room with good lighting, ambience, and good internet signal will suffice for the On-line class deliveries.

There are other difficulties of personal or private nature faced by each one of the Faculty.

Challenges faced by Candidates

Accepting On-line classes

There are a lot of candidates who are not comfortable with on-line classes.

1.1 Of course, on-line classes are not mandatory if the candidates are not ready for it. But considering that the industry requirements cannot wait, we have to adopt to available measures and provide the manpower.

Accepting the technology

Next generation candidates are computer / gadget savvy.

Internet Bandwidth (Candidates' Location)

Connectivity is an operational issue for the candidates as well. In remote places candidates still faces loads of connectivity problems. To handle such issues candidate should move to nearby place (cyber café, town area) where connectivity is good.

Screen size

Desktop and laptop has a good screen resolution but if a candidate is using mobile phone then it should be 10" and above or he/she can use tablet. Learning materials would be clearly visible and will not strain the candidates' eyes.

Lack of Interaction with Faculty

Candidates are encouraged to ask questions and get their doubts clarified during the on-line classes itself.

Lack of Interaction with Fellow candidates

In online classes the interaction with fellow candidate is very less. The best solution for this is to form a group on emails, WhatsApp / telegram / signal and if required, meet up after class hours.

Lack of discipline when studying from home

Candidates many times face this issue as there are many distractions at home.

Ideally we should put aside 3-4 hours daily for studies and no distractions should be allowed during such times.

Classes are not interesting enough

One way to face this mediocrity is to try and get the topics being covered in advance so that you can do some homework before the class begins.

Dropouts from Online classes

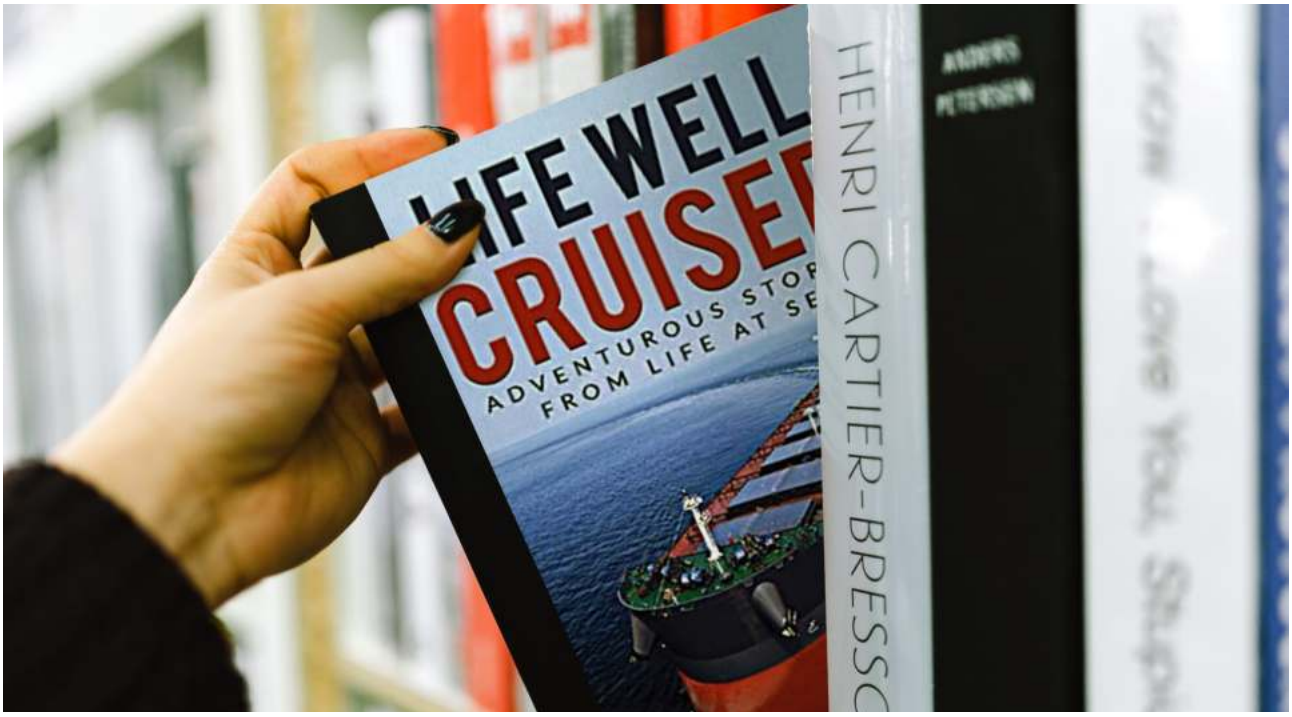
There have been many instances of candidates dropping out of course due to many reasons e.g., due to health reasons; connectivity issues; duty calls etc.

These are some thoughts we have shared from our experience. Focussing on such issues, on-line deliveries could be made more productive.

Ca. Anand Subramanian
Principal, HIMT College, Chennai.

Sanjeev Vakil,
CEO, HIMT, Chennai, India.

BOOK REVIEW

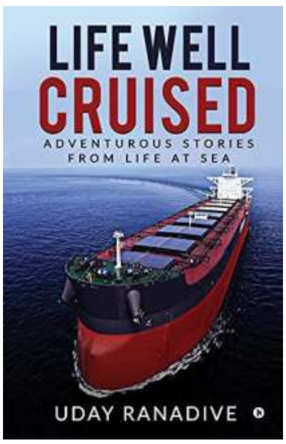


Review by: U.R.P. Sudhakar,
FIMarE

Ships have always fired the imagination of the general public and evoked a sense of adventure and romance. In the modern world, nearly 90% of the world's trade by volume is moved by merchant shipping. And yet, very little is written about the triumphs and tribulations of the seafarers - and even less by those who opted for a sea-going career themselves.

'Life Well Cruised', an autobiographical account by a senior marine engineer Uday Ranadive, is a good attempt that tries to fill this gap. The author, a DMET pass-out of 1969, records his varied experiences at sea. In an engaging style, his experiences are well communicated to an interested reader who could be a non-mariner. While doing so, he also takes care to detail the regular day-to-day functions and routines onboard.

In perspective it is to be observed that Ranadive's seagoing years (1969-81) belonged to an era when there was no internet connectivity. Social media, mobile phones and emails were unheard of. Shipboard engagements ran into almost two years at a stretch and news from home was received by mail that arrived intermittently (whenever the ship called on a port). Living conditions onboard were difficult with a very few ships boasting of air-conditioning. Those were the days before satellite navigation. For engineers, automation was still a novelty.



However, the seafarers of yesteryears had their share of fun too – thanks to long port stays, unexpected anchorages and shipboard comradery and the lasting bonds that held the personnel together and enabled them to function as an effective team.

The author narrates these conditions of the yesteryears graphically entwining with an account of his own journey – from being a cadet to chief engineer, making sacrifices along the way, being away from friends and family etc. He does this gracefully, without any bitterness or regret and with a fine sense of humour. It is his approach to a highly demanding profession that stands out in his writing. He attributes this tough preparedness to strength of character inculcated during his years in DMET, which brings the reader back to the importance of maritime training.

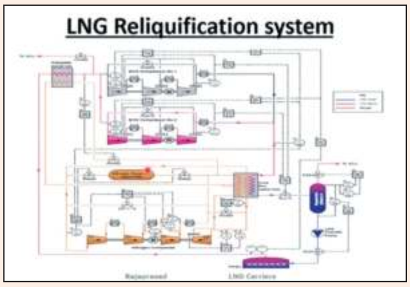
This account not only records the experiences of a marine engineer on several fronts, but also serves as a guide to young seafarers and all those boys and girls (in current times), who dream of embarking upon a sea career. The book is very well laid out and the maps depicting the author's sea voyages add to the readability. A few photographs perhaps would have made the book even more interesting, especially to the non-seafarer who may find it difficult to imagine the enormity of ships, engines and engine rooms. All in all, this highly readable memoir stands out as a welcome addition to the limited collection of seafarers' own records of life at sea.

[Published by Notion Press. 261 pages. Rs. 300. Available on Amazon]

IMEI, CHENNAI BRANCH: ONLINE TECHNICAL SEMINAR

The Chennai Branch organised an online Technical Seminar on 19 August 2021 at 1800h on 'LNG Carrier – An Overview' by Mr. Rajaprasad, Chief Engineer, Faculty-Hindustan Institute of Maritime Training (HIMT) Chennai.

Mr. Sanjeev S. Vakil, Hon. Secretary started with the ground rules for online sessions. Mr. Anil Kumar, Chairman, IMEI, Chennai, delivered the Welcome Address. The speaker was then introduced by Mr. Ramesh Subramaniam, EC Member. Mr. Rajaprasad, holding Steam and Motor CoC, and having vast sailing experience on LNG vessels, presented an overview of LNG career evolvement to the modern LNG carriers.



The informative seminar had a Q&A session which was moderated by Mr. B. Jaykumar, Vice Chairman and Mr. Muthusmy, EC Member of Chennai branch. The speaker responded well to many questions posed by the Members. The Vote of thanks was delivered by Mr. Suresh Shenoi, Treasurer, IMEI, Chennai.

Life is an Ocean

Life is like an ocean,
And we are the Chiefs and the Captains...
Sailing in it with waves of emotions
For which we need steering actions...

Smooth sailing and rough waves go in combination,
Don't fret as these are life's motions.
May the almighty provide us the strength and motivation,
So we may safely sail to our destinations!

Yes, we need to navigate with our best notions,
To reach our abodes with no distractions,
On this voyage we must have diligent devotion,
To not litter, not pollute our life of deep and wide Ocean!

– *Rashmi Tiwari*

IN THE WAKE

Rajoo Balaji

Corona Chronicles: Sayonara to the Socially Distanced Olympics

6 foreigners (come for the Olympics) were banned for breaking the pandemic restrictions/rules in Tokyo.

What did they do?

Two of them took a sightseeing trip out of the Olympic Village to the town.

Four others were doing Cocaine.

The touch of pandemic restrictions/rules were on podiums too… Apart from the 'No-Go', the Medal Ceremonies were all 'No-Touch'.

So the routine was: pick the medal-wear it-pick the bouquet-smile-wave and stand for the anthem…wave and walk away…

The Games at Tokyo could stand for the oxymoron, together separately.

Initially, the motto was amended to include 'together' (*Communiter*).

Citius, Altius, Fortius to *Citius, Altius, Fortius, Communiter.*

We can say, *C…A…F… spatium socialis* (Faster, Higher, Stronger, Together, Socially Distanced!)

Other Tokyo titbits

An interesting success story on the die-hard Women power (the Refugee Run):

Sifan Hassan of Netherlands won 3 medals (2G + 1B).

She got the bronze in the 1500m track event … (for which she had tripped and fallen down during the heats, got up and ran… ran… to come first and ran…in the finals to get the bronze!).

She ran again… in the race for 5000m and ran again… in the race for 10000m.

(BTW, she came to Netherlands as a refugee).

And…

Stats show that the athletes have gotten shorter, thinner and older (going by the trends till these Games).

The Games saw the lowest gender gap so far (5498 W to 5985 M).

On the 5000+ medals for the awards: Metal extracted (recycled) from smelting metals from electronic stuff including cell phones… (just about 78000+ tons of e-stuff with 6.2+ million cell phones was used).

Shipping Matters

The global merchant fleet value has been climbing and gone past the US$1.2trillion mark. Looking at the growth, the manpower crunch appears real. Looking at a growth potential of over 5% in the coming half a decade, there will be need for more to man the ships.

BIMCO Report (what else?) projects a demand of about 140000 jobs by 2025 (existing workforce of approx. 16×10^5 will not be sufficient).

This should bring smiles on the faces of those who are under training and the aspirants in India.

Container Count

The box freight does not appear to come down… so also the order book. Over 600+ on order and the additions is steepest. What is the preference? Surprisingly, the ULCC is not but the 13-16000 TEU vessels.

Some trends: most are coming out with scrubbers (HFSO still finding favour).

Many are coming out with scrubbers and also 'LNG ready' and more coming out capably burning LNG as they are launched.

2022 will see more of LNG energy...?

Tech Talks

Webinar exchanges...

Carbon Capture and Storage is yet to mature but the dialogues are on...

Some serious talks were on shipboard capture and the cryogenic technology.

The shipboard model will catch the CO_2, liquefy, store. Then what?

Use as feedstock to produce efuels(?) and synthetic methane in closed Carbon loop(?).

(? Will need help on these; will wait for more knowledge!).

More interesting is the cryogenic capture...

Catch the CO_2, pass through heat exchangers to cool, cool, cool and make it solid.

'Freeze the exhaust and make CO_2 dry-ice torpedoes'.

And then throw them into the seas (being heavier, they will sink).

Reaching the sea-floor they will remain there only as carbon hydrate.

(that should be a happy ending).

BTW, shipping lets out about 1 billion tons of CO_2. So, there will be plenty for all to capture...

About September

The September days can be paired/grouped for relevance:

5/9 Teacher's day & 8/9 Global Literacy Day.

14/9 World First Aid Day; 26/9 World Contraception day; 29/9 World Heart Day.

The 15/9 Engineers Day stands alone in the middle.

THE END VIEW

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

THE INSTITUTE OF MARINE ENGINEERS (INDIA)

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FOR MEO CLASS I - 3 DAYS

ABOUT THE COURSE

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OBJECTIVE

- **To facilitate the practical simulator-based training to students preparing for their Certificate of Competency.**
- **This course fulfils the simulator training requirement for Chief Engineer Officers at the Management Level, specified in Table A-III/2 of the STCW Code as amended, to provide knowledge and skills related to optimisation of fuel consumption, supervising and monitoring the combustion parameters, for safe and efficient operation and control of ship's machinery.**
- **To provide an opportunity for the learner to apply theoretical knowledge.**
- **To enhance operational safety and efficiency.**

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PERSON IN CHARGE : Ms. Anukampa Mallick

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