MARITIME RESEARCH CENTER

FOUNDATION FOR UNDERWATER DOMAIN AWARENESS

Underwater Domain Awareness (UDA) Framework

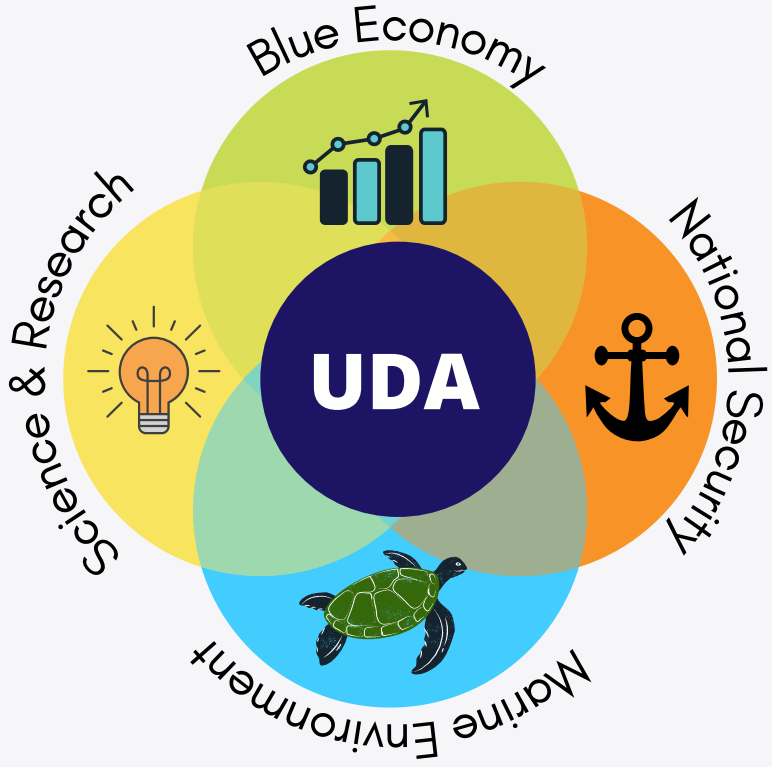
A National Policy Initiative for
Acoustic Capacity & Capability Building
- Whole of Nation Approach.

Interim Project Report

Submitted to

सत्यमेव जयते

NITI Aayog



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MARITIME RESEARCH CENTER
FOUNDATION FOR UNDERWATER DOMAIN AWARENESS

NIR TECHNOLOGIES DHWANI

UDA/IntRep/01 09 Nov 2021

Covering Note

1. Refer to the following:

(a) MRC policy proposal on Underwater Domain Awareness (UDA) and Acoustic Capacity Building – A National Capacity and Capability Building Initiative.

(b) Minutes of the online interaction held on 23 Dec 2020. (Copy Attached)

(c) Office Memorandum directing MRC/NDT to conduct the study on the topic mentioned in para (a) above. (Copy Attached)

2. The MRC undertook the study as directed vide the OM at para 1 (c) above. The objectives as per the directives have been followed and Shri Avinash Mishra, Adviser (WR&LR) NITI Aayog and Shri Arunlal K, Associate (WR&LR) were briefed at regular intervals, during the course of the study. The feedback received from the competent authorities, have been incorporated in the final report.

3. The MRC/NDT conducted a webinar on 12 Oct 2021, in collaboration with the National Institute of Advanced Studies (NIAS), Bangalore to discuss the acoustic capacity and capability building challenges & opportunities. The wide spectrum of experts and policy makers who spoke during the event, were unanimous to prioritise effective implementation of the UDA framework. Shri Suresh Prabhu, chaired the webinar and there were multiple former scientists from the Ministry of Earth Sciences (MoES), who have been instrumental in drafting the Blue Economy policy for the country. Details of the webinar are attached.

4. The interim report is attached herewith for perusal and comments. MRC/NDT has been progressing the UDA framework, since Feb 2017 and has remained focussed on the tropical littoral waters of the Indo-Pacific region. MRC has interacted with varied entities both in the government and otherwise to sensitise them on the UDA framework and also receive their participation & inputs. The proposal to NITI Aayog is to institutionalize the UDA framework at multiple levels and build a Whole-of-Nation approach towards achieving the national vision of SAGAR.

Dr (Cdr) Arnab Das
Founder and Director
Maritime Research Centre, Pune

F.No. 11(9)/2020 - WR
Government of India
NITI Aayog
(WR & LR Vertical)

Sansad Marg, New Delhi
Dated: 29.12.2020

Office Memorandum

Sub:- Minutes of the Meeting on proposal from Maritime Research Centre (MRC) to formulate National Policy for Underwater Domain Awareness (UDA) Framework

A meeting was held on 23 December 2020 at 11 00 hrs, under the chairmanship of Hon'ble Vice Chairman, NITI Aayog, to discuss the proposal from the Maritime Research Centre (MRC), Pune to formulate National Policy for Underwater Domain Awareness (UDA) Framework. The competent authority has approved the Minutes of the Meeting and is enclosed herewith for further action.

Encl: As Above

29/12/2020
(Arunlal K.)
Associate (WR&LR)

To:

1. Amb. Yogendra Kumar (Retd.), Adviser, MRC, Pune
2. Dr (Cdr) (Shri.) Arnab Das, Founder& Director, MRC, Pune
3. Shri. Avinash Mishra, Adviser (WR&LR), NITI Aayog
4. Shri. Sudhir Kumar, Adviser (Industries II), NITI Aayog
5. Shri. Neeraj Sinha, Adviser (S&T), NITI Aayog
6. Ms. Saloni Goel, Specialist (Natural Resources & Environment), NITI Aayog

Copy To:

1. P.S. to Vice Chairman, NITI Aayog
2. Sr. P.P.S. to CEO, NITI Aayog

Minutes of the Meeting on Proposal to Formulate National Policy for Underwater Domain Awareness (UDA) Framework

A meeting was held on 23 Dec 2020 at 11 00 hrs, under the chairmanship of Hon'ble Vice Chairman, NITI Aayog, to discuss the proposal from the Maritime Research Centre (MRC), Pune to formulate National Policy for Underwater Domain Awareness (UDA) Framework.

Participants:

1. Dr. Rajiv Kumar, Vice Chairman, NITI Aayog
2. Shri. Amitabh Kant, CEO, NITI Aayog.
3. Shri. Avinash Mishra, Adviser (Water Resources), NITI Aayog.
4. Shri. Sudhir Kumar, Adviser (Industry II), NITI Aayog.
5. Shri. Neeraj Sinha, Adviser (Science & Technology), NITI Aayog.
6. Ms. Saloni Goel, Specialist, Natural Resources & Environment, NITI Aayog.

MRC Team

7. Amb. Yogendra Kumar (Retd), Adviser, MRC Pune.
8. Dr(Cdr) Arnab Das, Founder & Director MRC, Pune.

Adviser (Water Resources) welcomed the participants and introduced the MRC team.

Amb. Yogendra Kumar (Retd), Adviser, MRC made the introductory remarks and mentioned that the underwater domain awareness enhances overall national capability through pre-empting security threats, better stewardship of our marine resources and their sustainable exploitation, monitoring climate change effects and environmental deterioration, and the larger aspects of coastal and maritime governance with their attendant strategic ramifications. This unique capability is critical for digital ocean and big data-driven technology and applications opening up vast opportunities for our strategic, scientific and entrepreneurial communities to work towards the

'first mover' advantage in the strategic waters: if not, others will move in. Global blue economy is likely to be US$ 3 trillion in 2030.

Dr(Cdr) Arnab Das, Director, MRC made a detailed presentation on the broad UDA framework and the activities of the MRC to justify the proposed policy papers for a holistic safe, secure, sustainable growth model driven by the digital ocean initiative.

It is stated that the policy proposal, to be developed through the NITI Aayog supported studies, aims at capacity building involving multiple stakeholder interface, establishment of a centre of excellence, and an MRC action plan for the draft UDA policy.

The immediate deliverables could be achieved by allowing MRC to work on an interim report over a period of three months to formalize the scope and scale of the national policy on the UDA framework. Post the interim report, the detailed draft national policy based on the finalized scale and scope can be awarded to be submitted over a period of one year. In the final phase, MRC could assist the NITI Aayog as the latter overseas the implementation of the approved national policy as regards possible gaps in capacities and supportive regulatory frameworks.

Director, MRC requested that NITI Aayog may support national capacity and capability building by sponsoring ten UDA fellowships right at the beginning, who will man the proposed Centre of Excellence during the implementation phase. Detailed proposal and budget requirements will be submitted based on the initial in-principle approval of the policy paper.

Discussions following the Presentation

The Chair appreciated the niche work undertaken by MRC on the UDA framework and invited comments from the members of the NITI Aayog team:

- CEO, NITI Aayog observed that NITI Aayog does not have the expertise to drive a subject like this and mentioned that the Ministry of Earth Sciences is driving multiple S&T projects for similar aspects.

He also mentioned that security aspects may be better handled by the National Security Council and the Ministry of Defence.

- Adviser (Water Resources), stated that it is essential to have a national policy on UDA framework. Since its present day applications are predominantly in the sphere of security and related aspects this could be piloted by Navy or Ministry of Earth Sciences.
- Adviser (S&T), opined that the Ministry of Earth Sciences is mandated to look at deep ocean related matters. However, since the UDA awareness involves multiple stakeholders NITI Aayog will be able to bring them together to develop a common policy framework.
- Adviser (Industry II), mentioned that such technologies can't be adopted as such since the Indian Ocean characteristics are different from anywhere else. There requires a spatial planning on what to do and where to do, and also should have an integrated framework approach.
- Specialist (Natural Resources and Environment), pointed out that the study on marine acoustics is more of a scientific study and could be better handled by Ministry of Earth Sciences or any research organisations. Subsequently, once a framework or scenario develops, NITI Aayog can integrate it with all relevant fields.
- Dr(Cdr) Arnab Das, submitted that the UDA framework requires massive efforts given the ongoing geopolitical and geo-strategic developments in the maritime domain and also the blue economic push by the Government of India. The overly security-driven approach tends to inhibit participation of other stakeholders and also restrict fast tracking UDA-anchored S&T induction. NITI Aayog driving this digital ocean project will ensure safeguarding our national interests in the long term and also providing the right structure to manage the safe, secure, sustainable growth model. Participation by organizations like MRC will bring agility and innovation in the maritime governance initiative.
- Amb. Yogendra Kumar (Retd), requesting the floor, mentioned that underwater sound propagation, as a field of study, provides a critical

basis for the emerging frontiers of digital ocean and AI-enabled meta data generation. This development is already emerging as a constituent of grand strategies of major countries and NATO is already developing an initiative in this regard. Gathering of big data is now a strategic imperative and others will take advantage of an opening if we are not ready. Our readiness is also necessary in terms of participation in the emerging international discourse, including its terminology and standards. There being multiple stakeholders in India in addition to defence, especially the private sector and the blue-tech entrepreneurs, working on an overarching framework would generate the synergy to drive this process forward.

Hon'ble Vice Chairman's summation and further directions

Summing up the discussions, the Hon'ble Vice-Chairman appreciated the MRC presentations noting that he was learning about the UDA dimension for the first time. He also noted that NITI Aayog's mandate excludes any security-related matters. He acknowledged the niche proposal and its relevance to the national policy requirement. He stressed on deeper understanding of the multiple dimensions of the maritime domain and the proposed policy framework. At present, himself and CEO do not clearly see NITI Aayog's role in piloting this. It is decided that the Advisers of Water Resources, Industry II and S&T may interact with MRC further and decide the way forward based on the outcome of such interactions.

Meeting concluded by 11 45 hrs.

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F.No. 11(9)/2020 - WR
Government of India
NITI Aayog
(WR & LR Vertical)

Sansad Marg, New Delhi-01
Dated: 09.08.2021

Office Memorandum

Sub:- Proposal submitted by Maritime Research Centre (MRC), Pune on Underwater Domain Awareness (UDA) and Acoustic Capacity Building – A capacity and capability building initiative

The undersigned to directed to refer to the proposal submitted by the Founder& Director, Maritime Research Centre (MRC), Pune on the above subject vide letter MRC/NDT/01 dated 20.04.2021 and to convey the approval of the competent authority for carrying out the work **on a pro-bono** (without financial support from NITI Aayog) basis.

2. The duration of the study will be three months from the date of issue of this OM.
3. Monthly progress of the work shall be intimated to the Adviser (WR&LR), NITI Aayog and an interim review will be held at the end of two months.
4. No activity covered under the said study should be at cross-purpose with the envisioned actions to be undertaken by the Ministry of Earth Science (MoES). It is suggested that the MRC should also consult MoES before commencing the study.
5. The activities with respect to this study should not have any adverse criticism of any current or recent policy or action of the Central Government or any State Government(s); or which can embarrass relation between the Central and State Governments or between Central Government and Government of any foreign State.

This issues with the approval of competent authority in NITI Aayog.

09/08/2021
(Arunlal K.)
Associate (WR&LR)

Dr (Cdr) (Shri.) Arnab Das
Founder& Director
Maritime Research Centre (MRC), Pune.
Email: director.mrc@foundationforuda.in

Copy To:

1. P.S. to Vice Chairman, NITI Aayog
2. P.S.O. to CEO, NITI Aayog
3. P.S. to Sr. Adviser (Science & Technology), NITI Aayog
4. P.P.S. to Adviser (Water & Land Resources), NITI Aayog
5. P.P.S. to Adviser (Industry II), NITI Aayog

Concept Note for Webinar on 12 Oct 2021

Blue Economy, Underwater Domain Awareness (UDA) and Maritime Security Challenges for India

The concept blue economy has emerged as a commonly accepted development pattern, and has been used in different ways across the globe. The concept gained attention when United Nations' Sustainable Development Goal 14 sought to "conserve and sustainably use the world's ocean, seas and marine resources" for the sustainable development as the guiding principle of ocean governance. The World Bank also understand the critical importance of ocean health has defined the concept as a means to "promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas." Since, some state activities are depended upon the status of the underlying ecological systems. Therefore, it is important to note that the potential degrade of marine ecology would invariably affect the jobs and economic growth in this segment of the global economy. India has fully realized the potential of ocean economy and need for sustainable development of the coastal and ecological system have identified key areas in the draft. India's Blue Economy Policy which aimed to accelerate employment and growth, while safeguarding the environment and in harmony with the UN Sustainable Development Goals.

India's "Vision of New India by 2030" highlights the Blue Economy as one of the ten dimensions of growth. The biological resources, ocean energy, extraction of ocean mineral resources and developing coastal tourism are at the top of the list in the Indian blue economy policy and much sought out by the policymakers to double the growth. India has already signed two agreements with the International Seabed Authority (ISBA) for exploration of Polymetallic Nodules and Hydrothermal Sulphide in the Indian Ocean. Each is rich in manganese, nickel, cobalt, and cooper, some of the minerals are key ingredients for making electric cars, solar panels and other modern electronic gadgets. The deep-sea mining of resources holds important position in transforming the Indian manufacturing sectors. India also has exclusive rights over living and non- living resources in the 2.37 million sq. km of its Exclusive Economic Zone (EEZ) and also committed to explore its EEZ by 2023. Under the United Nation Convention of Law of the Sea (UNCLOS) India's rights on the continent shelf can be extended up to 350 nautical miles. Of this, the first partial claim of about 0.6 million sq.km is already submitted to the Commission of Legal Continental Shelf (CLCS) and the second claim of 0.6 million sq.km is yet to be submitted. In this case India's right on the seabed will increase from present 2 million to 3.2 million sq.km in the near future. If UNCLOS ratifies claims then India can explore the area and exploit oil, natural gas and mineral resources in the extended area too. This will call for constantly monitoring and assessing the condition of the

oceans and ocean's resources and evolving/applying best practices for marine management. An understanding of parameters impacting the processes and resources on and below the ocean surface are needed for effective management and stewardship of the ocean's resources.

For sustainable utilization of resources in the Indian Ocean, India needs to develop ocean related capabilities, technologies and skillsets. At the same time, the situational awareness has become an increasingly prominent component of the Blue Economy where the state wants to have comprehensive knowledge of the situation at, or related to the seas. This is has led to the Maritime Domain Awareness (MDA) and the subset UDA. UDA can be a useful system both to monitor the subsurface threat as well as marine life, undersea environments, assess the geophysics, anthological activities, biological health environment of the Ocean. The subsurface threats in the Indian Ocean is increasing in the last few years my pose threat to India's economic security in the EEZs. Therefore, it is important to assess, how critical these threats are to India.

Against this background, NIAS – MRC, Pune organised a webinar on the Blue Economy, Underwater Domain Awareness (UDA) and Maritime Security Challenges for India. The seminar is an attempt to bring together experts and scholars in the field of maritime affairs to discuss various facets of Blue Economy and UDA.

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Summary of the Interim Report

The global community has recognized the strategic importance of the tropical littoral region and the Indo-Pacific Region has been declared as the geopolitical and geostrategic centre of gravity. The political, economic and military dynamics are extremely unique and any attempt at managing the region, needs a nuanced approach with good understanding of the local site specific dimensions. The Indo-Pacific Strategic Space is a maritime construct and thus the maritime capacity & capability building needs significant focus and strategic vision. The ongoing Maritime Domain Awareness (MDA) initiative has somehow not been inclusive and remained on the surface. The underwater component that may be referred as the Underwater Domain Awareness (UDA), needs far different approach, given its unique challenges and opportunities, particularly in the tropical littoral waters. The underwater domain includes both the marine as well as the freshwater systems.

India has demonstrated a significant shift from its continental mind-set in the 21st century and more and more maritime initiatives are being seen at multiple levels. The Security And Growth for All in the Region (SAGAR) vision of the Honourable Prime Minister is better served with an effective UDA framework. The Government of India has aggressively pushed multiple mega projects to complement the SAGAR vision. These include the Sagarmala, Inland Water Transport (IWT) and more. Additionally, the rapid development and urbanization needs to be supported with effective water resource management and water quality management. The UDA framework can effectively address these issues as well.

The acoustic capacity & capability building needs to be supported with deeper understanding of the local site specific challenges and indigenous R&D effort. The Science & Technology (S&T) has to be a driver for policy initiatives with an inclusive agenda to keep the interest of the local communities in mind. The policy & technology interventions along with the acoustic capacity & capability building has to be synergized across the stakeholders to optimize the resource development. The pooling of resources and synergizing of efforts is the key. A user-academia-industry partnership model has been proposed to weave together various government initiatives and stakeholders into one coordinated model. The Centre of Excellence (CoE) model has also been proposed to stitch together the entire capacity & capability building initiative. The academic and skilling modules have been developed to complement the CoE along with structured innovation ideas for start-up incubation.

The interim report is an attempt to bring out the challenges & opportunities of the UDA framework in the new global order and how, we need to steer our strategic initiatives to comprehensively navigate the safe, secure, sustainable growth model. The *to see, to understand and to share* approach is the most fundamental one, however we need to articulate the specific tropical littoral issues within that. The optimum model to deploy the limited resources in an efficient manner will be important. The outreach,

engage and sustain model has been presented to drive such a massive initiative in a seamless and effective manner.
The UDA Hackathon will be a very important dimension to engage with the Young India and also to encourage an innovation culture in the country. The disruptive growth that we aspire can only be established and institutionalized with a culture of innovation. Crowd sourcing of ideas is an age old method to involve the community and also to fast track development. The value of traditional knowledge needs no emphasis, and the only way to seamlessly map traditional knowledge to the modern S&T driven tools is to encourage a comprehensive understanding of the evolution of the human civilization with a structured framework. The sustainable growth is easily achievable if we value traditional knowledge. Underwater Archaeology is an important area of study to build on the traditional knowledge. The specific recommendation section in enclosure-7, gives a clear articulation of the takeaways from the interim report.

The submission of the interim report may be followed with the following:

(a) The interim report may be forwarded to the multiple policy makers, stakeholders and many more as listed in enclosure-6. The comments received from these entities will give a clear perspective on the way forward.

(b) A series of workshops, seminars and other forms of sensitization can be planned, to reach out to the stakeholders as listed in enclosure-6. MRC will be happy to coordinate the structured interaction.

(c) A strategic vision formulation can be planned with a committee of experts, coordinated by MRC. The committee will be authorized to interact with multiple government, corporate and non-governmental entities to draft a policy document for consideration by the government.

(d) UDA fellowships may be instituted to build a core team to drive this massive initiative in the future. This core team will also assist the committee for formulating the strategic vision document in the interim.

(e) India is moving at a very fast pace and may not have the time to wait for the committee to submit the detailed report. The setting up of the Centre of Excellence, the Group of Ministers and the Parliamentary Committee could happen halfway after setting up the strategic vision committee.

(f) The UDA Hackathon, could be initiated in line with the Start-up India initiative to accord enough priority to innovation for complementing the SAGAR vision.

(g) The Underwater Archaeology is a critical precursor to any new initiative. A parallel program could be started to encourage a multi-disciplinary effort and build a competent team to generate well informed inputs in strategy formulation.

(h) The Mausam project of the Ministry of Culture already attempts to build a maritime connect across the trade routes in the Indo-Pacific region. The skilling & knowledge outreach can also be added, to truly reflect our maritime leadership status.

Interim Project Report

Underwater Domain Awareness and Acoustic Capacity Building – A National Capacity and Capability Building Initiative

Maritime Research Centre (MRC), Pune

Introduction

A region which has found increasing resonance among the global powers recently, is the Indo-Pacific strategic construct. The Indo-Pacific being an outright maritime strategic construct, has become necessary for India to evolve itself into a major maritime power. It is defined as the ***tropical littoral waters*** of the Indian Ocean and the Pacific Ocean. However, the term tropical littoral waters, bring with it multiple unique challenges and opportunities.

The Indo-Pacific region has started seeing disasters originating from the seas and causing large scale destruction of life and property in recent times. This is owing to the global commons being accessed by diverse human populations for numerous activities, across multiple nations with varied regulatory frameworks. Environmental degradation, unsustainable natural resource extraction, non-scientific and immature tools for extraction of undersea resources along with a fragmented approach and non-integrated frameworks are the recipes for unsustainable growth. The region's geopolitical and socio-economic status has given rise to multiple security challenges mainly driven by the non-state elements. The marine forces that are equipped to handle security threats are more often than not the first responders for disaster management, pollution control, maintaining good order at sea and others with minimal preparation for such activities. Protection of the undersea natural resources is another threat we need to deal with. It has become necessary to take a holistic view of the threat & response mechanism and upgrade it to tackle the current threat.

The Government of India on its part has displayed significant strategic intent to alter the continental policy outlook. The ***"Security And Growth for All in the Region" (SAGAR)*** vision announced by the Hon'ble Prime Minster has been regarded as the most significant strategic declaration with a regional outlook far beyond its national boundaries. The Government of India has stayed true to their big SAGAR declaration, with mega projects like the "Sagarmala", "Bharatmala", "Inland Water Transport (IWT)" and more, to prioritise the maritime capacity and capability building.

A critical component of India's growth over the last two decades has also been rapid urbanization and the associated ***freshwater resource management*** crisis. The usage, apart from domestic consumption, ranges from manoeuvrable waters for river transport, exploitation of the living & non-living resources, climate control to the wellbeing of the local flora & fauna, disaster management and more. Communities in the inland and other regions who are dependent on freshwater systems have their own concerns to be addressed in a comprehensive manner. The deteriorating water quality leading to ***biological and chemical contamination*** is increasing at an alarming rate and requires immediate intervention before it transitions into a calamity.

The increasing activities both in the maritime domain and the freshwater systems also expose us to vulnerabilities related to accidents and loses of life at sea and other freshwater systems. The ***Underwater Search and Recovery (UWSAR)*** thus, essentially pertains to search, recovery and salvation of high value objects that have been lost at the bottom of the water body. The UWSAR traditionally, translates to handling emergencies in the offshore and shallow water regions. The UWSAR, despite being expensive, has critical scientific significance and engineering practical value for improving safety and reliability. The UWSAR is an area of concern and needs to be addressed in a comprehensive manner with high-end S&T tools.

The starting point for any initiative towards effective maritime governance with a coherent and systematic approach would be ***Maritime Domain Awareness (MDA)***. MDA is rooted in its ability to effectively monitor what is going on at any given moment in the entire maritime space[1]. In our conventional understanding of MDA, we ignore the underwater part of it and in doing so, underestimate the threats as well as the opportunities in the undersea domain. The easy access to technology and technical knowhow has made it easy for both nation states as well as non-state actors to deploy sophisticated underwater devices causing large scale damages and launching precise attacks on their adversaries. The asymmetry in the underwater threat makes it extremely difficult to counter via conventional means.

The MDA globally, remained a security construct and continued to be driven by maritime forces with far less transparency and minimal involvement of other stakeholders. The growing maritime activities and increasing awareness on the ***Blue Economic*** potential necessitates that we build acoustic capacity and capability to explore and exploit these opportunities in a nuanced manner with minimal damage to the ecosystem. Effective maritime governance is the key to comprehensive management of challenges and opportunities. Even from a security construct, the underwater component of MDA that is referred to, as Underwater Domain Awareness (UDA) has still remained a far neglected and fragmented on a global scale as well.

The challenges as listed above would require participation of far too many stakeholders and policy makers. The R&D effort and the associated resources required for ensuring effective UDA in the tropical littorals of the IOR cannot be managed within the existing budget and would require widening of the scope and mandate across the stakeholders. A comprehensive UDA framework, by encouraging ***pooling of resources*** and ***synergizing of efforts*** across the stakeholders needs to be evolved. The Maritime Research Center (MRC) is working towards progressing the UDA framework to provide policy & technology intervention along with acoustic capacity & capability building across the spectrum as presented in enclosure-1.

[1] The MDA as defined by the International Maritime Organization (IMO), is the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy or the environment. The maritime domain has been defined as “all areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo and vessels and other conveyances”.

Challenges and Opportunities

The Indo-Pacific region has its unique challenges when we look at the ***safe, secure and sustainable growth models***. The tropical littoral waters need to be dissected to understand the existing issues while we plan for the future. The socio-economic and socio-political factors have their own bearing on the strategic outlook.

The tropical waters translate to rich bio-diversity and thus, attract significant economic interest among groups within and outside. In the absence of mature regulatory framework and an effective monitoring mechanism to manage the resources, ***sustainability*** becomes a big casualty. The ***local communities*** are currently unable to get value for their catch while the ***extra-regional elements*** are exploiting the resources. There is significant interest among the extra-regional powers regarding the abundantly available mineral resources in the undersea domain. The nations in the region are pre-modern states with limited resources and know-how, thus making them ***vulnerable to manipulations***.

The tropical waters have a significant impact on the ***sonar performance*** as well[2]. The ***sub-optimal performance*** of the sonars deployed for any acoustic survey below water is a major limitation for any application, both military as well as non-military. The tropical littoral impact is not only manifested as poor performance in terms of the range of sonar detection, but also in its classification. This translates to, many features not being available to the user in the tropical waters.

Acoustics has multiple dimensions when we look at the UDA framework. The ***amplitude, frequency and the phase characteristics*** of the acoustic signal have their own unique sensitivity to the application. The ***source-path-receiver model*** has to be understood before we assess the impact of the underwater medium, on the desired signal of interest. The source is the origin of the acoustic signal that has to propagate in the underwater medium (the path) and gets modified by the underwater channel characteristics. At the receiver, the recorded signal has to compete with the ambient noise to be detected by the receiver. Enclosure-2 elaborates on a couple of interesting ***acoustic dimensions of the UDA framework***. The impact of the tropical littoral underwater medium will be significant and could potentially undermine the received signal at the receiver's end.
The source-path-receiver model has a unique perspective in the tropical littoral waters. The uniqueness comes from the acoustic propagation along the underwater channel (path) that gets severely modified due to the tropical littoral conditions. The

[2] The depth of sound axis that determines the availability of the SOFAR channel is found at a greater depth in the tropical waters (approx. 1800 m) compared to the polar region (approx. 100 m). This leads to multipath propagation in the tropical waters even at depths of 2000 m. The conventional hypsometric definition of deep waters for depths greater than 200 m, corresponding to the edge of the continental shelf, is not valid acoustically in the tropical waters. The tropical region also means higher surface disturbances and large variation in the bottom types. This combined with higher multipath propagation translates to significantly high acoustic signal deterioration. Thus, the Indo-Pacific region can be considered to be shallow waters acoustically, even up to 2000 m depth, which translates to sub-optimal sonar performance for most of the region. The high bio-diversity further leads to volume distortions and high ambient noise due to biological noise.

modification spans across the amplitude, frequency and phase making the received signal unrecognizable for multiple applications. This is extremely critical as the entire policy & technology intervention requires indigenous site specific data driven inputs to remain insensitive to the medium impact on the acoustic signal. The ongoing effort to import policy & technology interventions from the west has been a cause of concern as they are not able to account for the tropical littoral conditions.

The underwater domain will remain a major component of the MDA. However, the complexities and the uniqueness of the challenges and opportunities will dictate the need to have a specific focus in our approach towards dealing with the underwater domain. Currently, the generic understanding of the maritime domain is not good enough to deal with the complexities of the underwater domain. The basics of any domain awareness are three fold, ***To see, To understand and To share*****.**

To see: To see includes the sensors and the platforms (on which these sensors will be mounted) that will gather information across the entire EEZ and beyond. These platforms will include ***static surface & sub-surface buoys*** and ***dynamic entities like ships, sub-surface platforms like submarines and Autonomous Underwater Vehicles (AUVs)***. The underwater sensors and their capabilities to see far will be major areas of concern. The vast area cannot be practically mapped by conventional sensors only for security purposes. Initiating a massive security exercise to deploy sensors is impractical resource wise and also may not go down well with regional sensitivities diplomatically. Strategies with the capability of collecting data from all possible seagoing vessels or enterprises will have to be deployed and integrated to the data centre. Environmental and academic research is a very potent means to camouflage security missions. Resource allocation for blue economy with a strategic objective of security will make it more viable both economically as well as politically. Protecting the privacy of the data is something we need to focus on.

To understand**:** To understand or analysis is a critical component that may help overcome some of the deficiencies of data collection. The analysis could be centralized or distributed based on resource availability and the strategy deployed for data acquisition. The first concern would be to minimize medium distortions from the received data and also ensure data integrity by verifying corruption and errors. ***Deep learning methods*** are available today, which can manage multiple data sets and provide the big picture. Also, High Performance Computing (HPC) infrastructure will be required to manage the Big Data in real-time. The ***advanced underwater acoustics and signal processing*** may be deployed at the centralized facility or the distributed nodes. A mix of Commercially Off The Shelf (COTS) equipment for data collection and also specific prototype design of sensor and data acquisition systems may have to be developed to be installed, across static and dynamic platforms to map the entire area. The stakeholders may be integrated into this entire programme in a comprehensive manner to expand their data collection into the big infrastructure. All kinds of data collections will seamlessly get channelized into the central systems with safeguards for data privacy for the individual users and metadata available for security analysis and policy formulation. Digital India, addresses many of the issues related to digital data and its handling, ***Digital Oceans*** is the version we need to focus on.

To share*:** To share or the networking of the systems for seamless data and information flow from source and destination to the central system is a critical component. The real time processing and networking is the key, in order to make some meaningful impact. The networking in the RF domain has progressed sufficiently to meet this requirement. The sensor networks have to be configured to bring the underwater signals above water to take advantage of the advances in RF. The old fashioned ***Sound Surveillance System (SOSUS) set up by the United States during the Cold War period is a thing of the past and needs to evolve into its modern form like ***Deep Reliable Acoustic Path Exploitation System (DRAPES)***. We have to work on a very innovative model that is a mix of DRAPES and others, keeping in mind the tropical littoral issues and also the high traffic density in the IOR. The entire ***hardware and software*** needs to be planned effectively across the stakeholders and the applications. The overlaps and the diversities will have to be appreciated and the design of the new systems for strategic and tactical management of the challenges and opportunities have to be accounted for. Site specific R&D backed by field experimental validation is needed to capture the uniqueness of the tropical littoral waters. An inclusive model will be the key to success given the complexity of the entire UDA framework.

Underwater Domain Awareness (UDA) Framework

The UDA framework proposed by the MRC is presented in enclosure-1 in detail. The ***to see, to understand*** *and* ***to share*** fronts are required by all the stakeholders to comprehensively address the requirements of the UDA framework. The figure-1, below presents the schematic of the UDA framework.

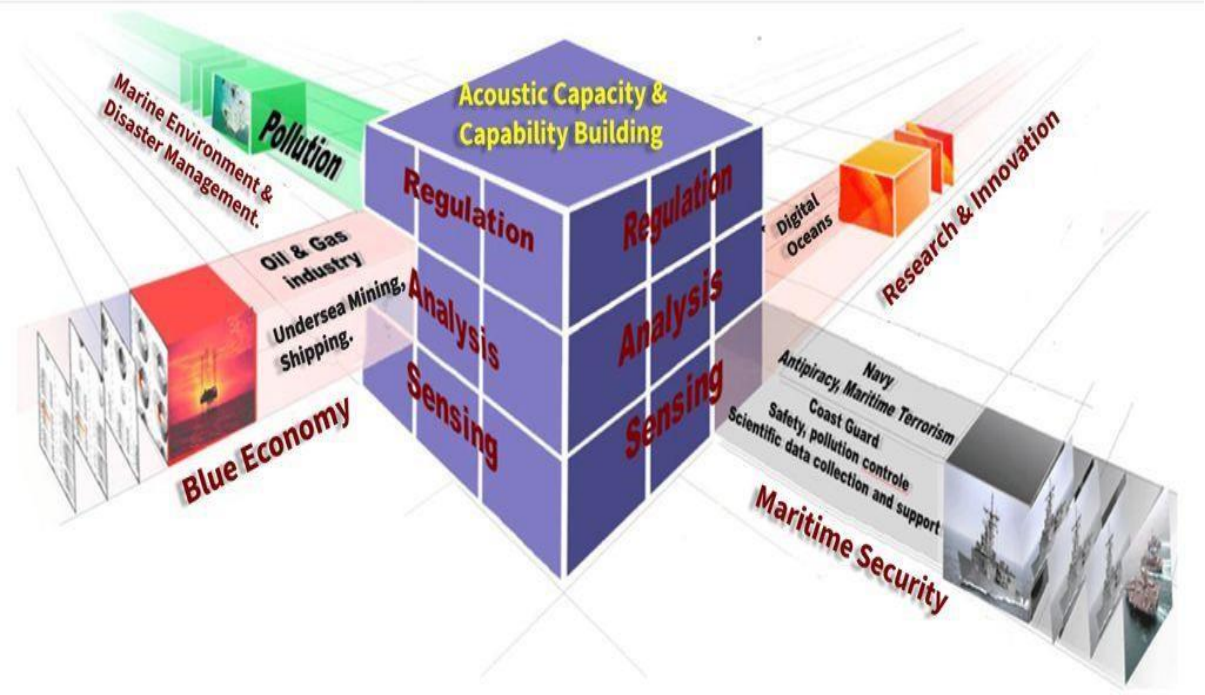


Fig. 1 Comprehensive Perspective of Undersea Domain Awareness

The smaller cubes in figure-1 below represent the multiple aspects of the UDA framework in terms of the policy & technology interventions along with the acoustic capacity & capability building requirements. Each cube translates to a specific project pertaining to a single or multiple stakeholders and also requires multi-functional participation from the user as well as the industry. The bottom up approach will require deep research and understanding of the local situation with detailed sensing and data collection. The data will have to be cleaned for any corruption due to sensing errors, environmental fluctuations, human interventions etc. The data will then require to be annotated and associated with the other correlated events for an enhanced processing output. Diverse data sets with time stamping will have to be collected for the next level of data processing. Signal processing with high performance computing infrastructure will be critical for the precise and application specific interpretation. The interpretation will require involvement of multi-disciplinary experts and diverse stakeholders. The policies have to be grounded to the local requirements of the communities and social engineering will be a major component of the entire exercise. The maritime governance mechanism can be effectively realized through this unique UDA framework in a structured manner towards a whole-of-nation approach.

The proposed framework ***brings a defined structure*** to the entire UDA initiative. The authorities dealing with policy & technology intervention and acoustic capacity & capability building along with supporting agencies can drive the entire effort seamlessly without any ***duplication or gaps***. The government can also prioritise the allocation of resources and activities according to the national requirement and geopolitical & geostrategic developments. Efficient and effective governance can be ensured with such a structured approach. Multiple government, corporate and nongovernment organizations are undertaking various efforts towards making the country self-reliant on diverse issues. However, at times it is observed that in the absence of a structured framework, there is duplication of efforts and poor accountability of responsibilities. The UDA framework as proposed by the MRC, if driven effectively can seamlessly integrate multiple agencies and institutions across the spectrum towards a single national effort.

The ***demographic advantage*** that we talk about can be better managed with this kind of framework. The new opportunities that are emerging can be utilised effectively with such a structured approach. Connecting young India to new opportunities has its own set of significant challenges in terms of ***skilling & academic qualification*** at the supply side and then the stakeholders & industries on the demand side. The multidisciplinary capacity & capability building must have a clear association with the stakeholders as well as the industry requirements. The young India while pursuing their academic & skilling programs can associate with one of the small cubes and connect with one or more stakeholders or industries suited to their capabilities. The industry & the stakeholders in turn can also participate in the capacity & capability initiative to shape them for their specific requirements and build pipelines to have assured career opportunities.

The ***multiple skilling and academic programs*** have been identified and formulated by the MRC to build on the acoustic capacity & capability across the stakeholders & policy makers. The programs are specifically designed to build human resources with

the purpose of driving policy & technology interventions as required. These include acoustic survey, underwater bio-technology and AI & robotics to manage a broad spectrum of skilling and academic requirements for the entire UDA framework. The details of the three programs have been placed in Enclosure-3.

The ***Acoustic Survey*** program is relevant to multiple stakeholders & industries across the marine and freshwater systems. Mega projects conceptualized by the Government of India include the likes of Sagarmala, Inland Water Transport, Water Resource Management, and many more. The ***Underwater Bio-Technology*** is similarly relevant to the pharma industry, fisheries, aqua-culture, seafood industry and many more. ***Artificial Intelligence (AI) & Robotics*** will be the main requirement for the ***massive Digital Oceans initiative*** that will need to be activated going forward for ***effective maritime governance***. Multiple dimensions will have to be addressed. Specific requirements of each stakeholder and the industry are mentioned in the detailed document attached in Enclosure-3.

Developing nations have their own challenges like resource limitations, leadership crisis, technology challenges, governance issues of coordination among stakeholders and more. A systematic and comprehensive strategic way forward will help significantly. The UDA framework as proposed by the MRC is not a mere underwater extension of the MDA concept but also comprehensively addresses the ***Safe, Secure and Sustainable Growth model*** critically required to overcome the economic, political and physical challenges of the Indo-Pacific region. It is a very broad framework that will require far more detailing to address the finer points in a holistic manner.

Acoustic Capacity & Capability Building

The Indo-Pacific construct, almost translating to an India-China rivalry in the Indian Ocean Region (IOR) needs to be understood from the capacity and capability gap perspective between the two. The Chinese have systematically built their Submarine capabilities to not only meet there own requirements but also to export to other regional allies. The Chinese provide a cheaper option for the developing nations compared to the traditional European military suppliers like Germany, France and others. China not only supplies these to such countries but in return also controls their military actions in multiple ways. With support bases in the IOR, even conventional diesel submarines more suited to the littoral waters in large numbers from China can pose a formidable threat for India, if not detected on time. Such military exchanges in more measures will also translate to economic dominance which is the core of geopolitical and geostrategic power-play in the region.

The Chinese have not just built military hardware in terms of platforms to lead campaigns both in South China Sea and the Indian Ocean, but they have also systematically worked on their ***soft acoustic capability building*** in a big way. "***The 'Undersea Great Wall (UGW)***' project is an ambitious program announced by the China State Shipbuilding Corporation (CSSC) in Dec 2015. It is a part of a focused underwater capacity building initiative by the Chinese government since 1980 that has been openly announced only recently. The CSSC announced that it would construct an underwater observation system in the disputed South China Sea region. The UGW

is part of the major project to set up an offshore observation network by 2020 released by the State Oceanic Administration. The stated larger vision of the Chinese government is to be seen as a global maritime power with a network covering coastal waters, the high seas, and polar waters. The Chinese have realized and accepted their limitations in the acoustic capabilities and have worked systematically with strategic vision and a nuanced approach. The UDA capacity and capability building has been undertaken in a holistic and long term planned manner. They have taken help even from their adversaries to build their UDA capabilities.

The acoustic analysis capabilities globally, have remained limited to a certain small group of countries including US, France, Japan, Australia and members of the Nordic Acoustic Association (NAA). The tropical littoral Anti-Submarine Warfare (ASW) has been a recent phenomenon and some of these countries have done well to invest in, and develop capabilities to overcome the challenges. The Americans realized the Chinese belligerence in the maritime domain particularly in the South China Sea (SCS) only towards the end of the 20th century. The ASIAEX was a massive Shallow Water Acoustic Measurement (SWAM) experiment they planned right at the beginning of this century. Initially, six US universities led by University of Washington planned the phase-1 of the project and in the phase-2, 20 other universities from China, Taiwan and others were included. It was a very interesting construct and had far reaching geopolitical overtones. The US needed data to overcome the tropical littoral challenges in the SCS, so the entire experiment was funded by the Office of Naval Research (ONR), but was led by the Academia to camouflage the strategic intent. ASIAEX was only the beginning and the US government routinely undertook acoustic data collection post that by streaming acoustic arrays and deploying underwater drones in the SCS. The Chinese realized and accepted their limitation of undertaking such large scale SWAM experiments and so they participated with the Americans as a way to learn. They followed it up with massive drive culminating in the Underwater Great Wall project. Recently, in December 2016, when Mr. Donald Trump was elected and was yet to take over as the President, the Chinese seized a US underwater drone deployed from USNS Bowditch. The incident was an official declaration, by the Chinese that they are now confident of taking forward their own acoustic development programme and would not accept any US snooping in their waters.

The geo-politics in the IOR is fragmented and the extra-regional powers have made it a fertile ground to cause mischief. Most of the nations here are pre-modern states with meagre resources for socio-economic development, but they seem to spend maximum on military hardware due to the bogey of instability and volatility being propagated by the extra-regional powers. Even within these nations, multiple arms are fragmented to pool in resources and synergize efforts to achieve superiority in terms of S&T. India in the IOR, has an opportunity to play a leadership role with the UDA framework and optimize resource deployment across stakeholders.

The ***deep Vs shallow waters concept needs to be defined acoustically*** before we attempt to appreciate the physical challenges in the ***tropical littoral waters of the IOR***. The hypsometric definition of deep waters is the edge of the continental shelf that marks the Exclusive Economic Zone (EEZ), wherein the 200 nautical miles end with an approximate water depth of 200 meters. Thus, hypsometrically depth below 200 meters is defined as shallow. However, acoustically whenever we have higher number

of interactions with the surface and bottom boundaries (that translate to higher distortions due to multipath fading) they are defined as shallow waters. Multipath propagation is governed by the depth of sound axis that provides the SOFAR channel to minimize the surface and bottom interaction due to refraction towards the sound axis. The depth of sound axis varies, from as low as 100 meters near the poles to as high as 1800 meters near the equator. Thus, in the IOR we are ***hardly likely to witness any deep water acoustically***, justifying the poor sonar behaviour. To compound matters, the tropical region further adds to the surface fluctuations and variations in the site-specific bottom variations thereby increasing the multipath distortions. It is also known that the rich biodiversity in the tropical waters contributes to the volume distortions of the sonar signal propagation making it a cocktail of complex signal modifications due to the local medium conditions.

The order of performance deterioration is 70% in the IOR, compared to the ***Greenland Iceland United Kingdom (GIUK) Gap*** of Cold War fame. The import of technology as demonstrated by multiple nations in the region has not paid any dividends in the absence of local efforts to overcome the medium challenges. Field experimental efforts require massive resource deployment and efficient utilization of know-how and long term sustained initiatives. Political instability, economic limitations and technological challenges are major impediments for any progress in the region.

The post-Cold War period saw two major developments as far as the UDA is concerned. The first was the shift in the underwater security activities (that has been the major driver for technology development) towards the littoral waters more popularly called littoral ASW. The second was the less aggressive and ineffective acoustic capacity and capability building thrust due to perceived lack of threat, driven by the American hegemony. However, the early 21st century is seeing a significant revival of the acoustic capacity and capability building, particularly to overcome the tropical littoral challenges. This would involve massive SWAM experiments in the region to collect acoustic data followed by signal processing efforts to model the underwater channel and ambient noise.

The SWAM experiments will require two main inputs. First is ***platforms*** to access the nook and corners in the undersea domains and the second is the ***signal processing*** abilities that will pre-process the data and undertake effective processing to derive meaningful inputs. The conventional ship-borne deployment of sensors has not yielded the desired results and are prohibitively resource intensive to cover the massive area that needs to be studied. The ***Underwater Gliders*** have proven to be the most suited platform for undertaking acoustic surveys in the underwater domain specifically for oceanographic data collection. The buoyancy engine driven underwater gliders are slower, cheaper, have long endurance and are less noisy thus ideally suited for data collection in acoustic surveys. These platforms can be deployed in large numbers to cover huge areas and then be stitched together for data analysis. They are amongst the recent advancements in the ***Autonomous Underwater Vehicles (AUVs)***. However, since they are not propeller driven, they can be used for extended acoustic data collection as well as they have low noise and long endurance.

It needs to be appreciated that acoustic capacity and capability development in the tropical littorals can only happen with massive SWAM experimental initiatives. These

are extremely resource intensive and need to be funded at a different scale and also supported with cutting edge technology both for hardware as well as software. Pooling of resources and synergizing of efforts is inescapable both at the national as well as the regional level. India will do well to involve its new found ***Quadrilateral Security Dialogue (QUAD)*** partners for this purpose.

Digital Oceans

Digital Oceans has to be an integral part of the ***Digital India*** initiative in order to ensure seamless transition into the new India we dream off. The regulatory aspects and the monitory mechanisms have to be effectively implemented and managed. The underwater domain has its unique challenges & opportunities leading to the conceptualization of new framework, with the ability to comprehensively incorporate the new vision. Digital Oceans will significantly enhance transparency and the corresponding governance mechanism. The efficiency and effectiveness of the entire system across the stakeholders will depend upon the realization of the Digital Ocean framework. The privacy of the stakeholders has to be protected whilst bringing significant efficiency into the system. The broad UDA framework needs to be dissected into individual S&T areas that have relevance across multiple sectors and applications. In this section we try to present a few such areas that are representatives of the vast UDA framework across marine and freshwater systems.

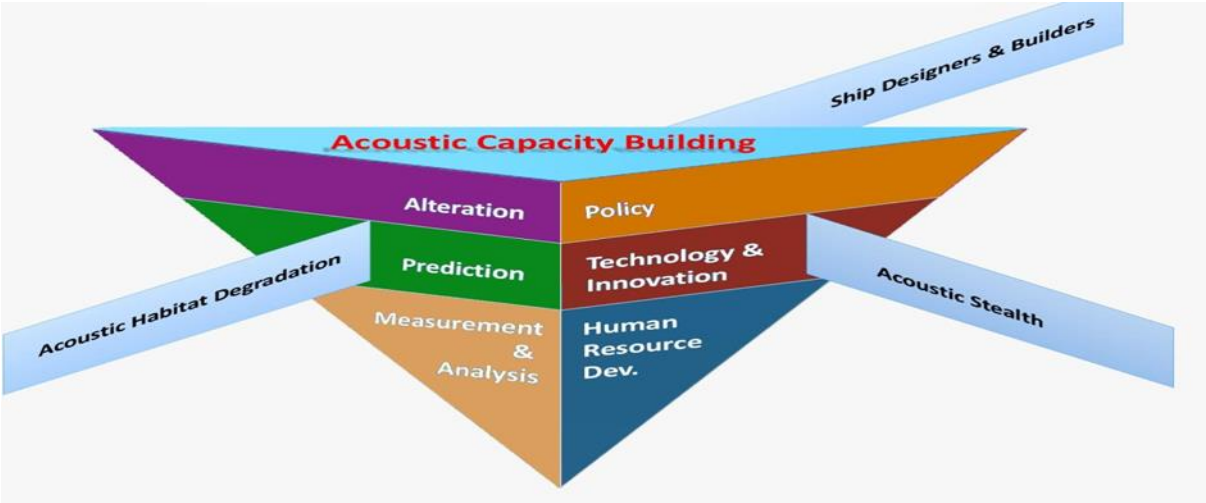


Fig. 2 Underwater Radiated Noise (URN) Framework

Underwater Radiated Noise (URN) Management is one of the most critical areas across military and non-military applications. The increasing shipping traffic across varied sectors starting from cargo in the high seas to coastal and inland waterways, has had a huge impact on the underwater acoustic characteristics. The radiated noise from the marine vessels generates a low frequency sound that overshadows the low frequency spectrum of the ambient noise in the water bodies. The low frequency noise suffers minimum attenuation in the underwater domain and thus has a significant impact over thousands of kilometres. Any underwater deployment of sonars for surveillance or marine mammal monitoring gets severely degraded due to poor Signal-to-Noise Ratio (SNR). Acoustic stealth for military deployment of platforms and

acoustic habitat degradation for marine mammal conservation requires effective URN management. The shipbuilding and ship repair departments also need to take note of the URN management aspects and deliver ships with requisite URN levels. Opportunities in this domain exist right from URN measurement & analysis to prediction and deception/alteration. Given the size of the shipping fleet in the merchant marine and the naval warships, this is a huge area available for technology as well as policy intervention. Acoustic capacity & capability building has innumerable dimensions. The figure-2 presents the multiple aspects of the URN management. It also brings all the stakeholders together in a seamless manner.

Sediment Management is another major opportunity for significant military and nonmilitary applications. The broad areas of concern are freshwater resource management, flood control, navigation for inland water transport, port management, deployment of amphibious vehicles in water bodies and many more. There are significant military requirements in terms of logistics and movement of military assets across water bodies. Maintaining safe navigation and all-weather access across these water bodies could be a major challenge. There has been significant focus on port-led growth under the Sagarmala initiative and also the multimodal connectivity across waterways. These require massive acoustic capacity and capability building to ensure uninterrupted operations in our water bodies.

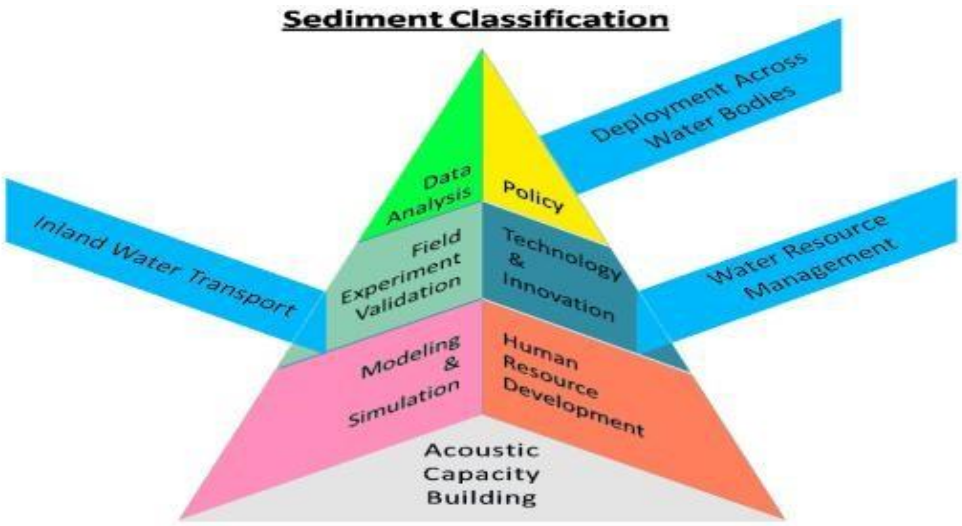


Fig. 3 Sediment Management Framework

Sediment management originates from prediction and prevention of the siltation process, de-siltation and also disposal of the silt. The tropical littoral waters have very high flow causing high siltation. De-siltation needs to be done in a scientific manner in order to ensure viability of the said projects. The acoustic survey and sediment classification is the key to the entire process. The volume of silt is a huge challenge from the perspective of removal as well as disposal. Dredging has multiple options with varying cost based on the nature of the silt. The disposal of the silt has become an impediment given the logistical cost and also non-availability of dumping grounds. Precise sediment classification can ensure economic viability of the entire de-siltation process. There is significant wealth in the silt and with proper sediment management this could turn out into a waste to wealth story. Figure-3 represents the multiple aspects of the sediment management framework. The stakeholders can seamlessly

synergise and pool their resources to manage this effectively. The policy and technology interventions can be managed efficiently with enhanced acoustic capacity and capability building for sediment management.

Aquaculture and Digital Oceans The aquaculture and fisheries industry in India has significant potential as a blue economy opportunity. The tropical littoral waters are known breeding grounds for shrimp farming and given the high value of shrimps in the global market, present a huge opportunity. However, shrimp farming is a high-risk venture due to disease outbreaks, environmental fluctuations, lack of scientific awareness etc. The small farmers are unable to sustain these ventures due to the absence of financial support from insurance companies and banks. The unorganized sectors face major growth challenges due to inadequate policy support from the governments as well. India, with a coastline of over 7,500 km has a massive opportunity to build this industry and help the community engage in productive ventures. Digital oceans is the only way forward to develop a deeper understanding of the underwater conditions and fluctuations. Once we understand the patterns, the uncertainties of the environment, affecting the production output could be minimized with better interventions. A lower count of uncertainties and enhanced predictability of the entire process will encourage participation of the financial entities to support such sectors. The policy and technology interventions for enhanced and sustainable aquaculture & fisheries is a major requirement. India has failed to take advantage of its vast tropical littoral waters due to lack of prioritization of the digital oceans initiative. The acoustic capacity and capability building is again a key requirement for Digital Oceans and if managed well, could be a significant export opportunity for the skill India initiative.

There is a substantial strategic angle to shrimp habitats and generating a deeper understanding of their soundscape. They are known to be the loudest of the creatures with vocalization ranging beyond 200 dB ref 1 □Pa at 1 m. Even the biggest mammal on earth, the blue whale's vocalization is of the order of 196 dB ref 1 □Pa at 1 m. The whales are few in numbers (in single digits) in a group, there are millions of shrimps in a shrimp bed. There have been incidents in the past when a submarine has been acoustically swamped due to snapping shrimp vocalization. The Indo-Pacific region is going to be a major maritime theatre for submarine deployment in the near future. The nations within have also acquired strategic submarines and UDA for submarine deployment requires no emphasis. There are multiple other aspects of UDA that need to be prioritised for strategic security purposes ranging from maritime intelligence against undersea intrusions, effective deployment of subsea vehicles, mitigating the sub-optimal sonar performance and more, which demand high priority in the ongoing geopolitical and geostrategic developments.

Massive acoustic capacity & capability building will be required to manage the entire Digital Oceans initiative at the national & regional level. The seamless stakeholder integration will be the key and can only be driven by macro and apex level policy intervention. The technology intervention will have to be extremely nuanced and mapped to the ground realities. ***Traditional knowledge*** will play a major role in mapping the modern ways to the local site specific characteristics. The capacity & capability building has to generate substantial human resources with diverse understanding of the multidisciplinary issues to make it happen.

Way Ahead

High-end technology developments globally have taken place during the Cold War period. Even the underwater technology developments till date have largely taken place as part of the super-power rivalry between the Americans and the Russians. They have deployed huge resources to generate a better understanding of the undersea domain in order to ensure enhanced sonar performance. However, the engagement during the Cold War period was mainly seen in the temperate and polar regions. The Cold War had different geopolitical and geostrategic realities. Military spending was not questioned and military projects did not require any environmental clearances at all. The post-Cold War era is a completely different political scenario. Even in the US and other democracies, the leaders have to balance socio-economic requirements along with national security requirements. The environmental clearances cannot be bypassed for national security projects. Pooling of resources and synergising of efforts across the stakeholders is the only way ahead. Geoeconomics has taken the high ground and geopolitics has to match the economic growth engine trajectory.

The tropical littoral challenges and opportunities have to be driven by S&T and site-specific R&D. This requires high-cost infrastructure investments and a long-term commitment to develop know-how. ***User-Industry-Academia*** partnership is inescapable. All the stakeholders have to be committed on a long-term basis to this model. Beyond the nations, the ***regional frameworks*** will make more sense and will also keep the extra-regional powers at bay. The fragmented stakeholder interactions within the nations and also in the region is a major impediment in ensuring higher synergy. Digital Oceans driven by the UDA framework can be a game changer. It will be a paradigm shift for ensuring safe, secure, sustainable growth for everybody in the Indo-Pacific Region.

India has taken multiple steps to build maritime infrastructure and the SAGAR vision demonstrates significant seriousness on the part of the Government of India. A User Academia-Industry partnership model is presented in figure-4, for realising the Digital Ocean dream. It binds together multiple announcements from the Government of India and also the stakeholders both in the marine as well as the freshwater systems.

The figure-4 brings all the core R&D domains on one side of the funnel and the government initiatives on the other in order to form the three main pillars of the UDA framework. The effective policy intervention, innovative technology support and the acoustic capacity & capability building will seamlessly come together across the stakeholders. The UDA framework proposed by the MRC has significant merit for a "***whole of nation" approach***.

The User-Academic-Industry can be implemented on ground with the setting up of a ***Centre of Excellence*** to build on all the five major requirements of research, academia, skilling, incubation and policy. The ***research*** will be multidisciplinary to build on the core capabilities. The S&T will have to be complemented by the socioeconomic, socio-political and socio-cultural aspects. Field experimental R&D will require substantial focus. The ***academic*** programs have to encourage a multidisciplinary

approach and project-based learning to incorporate a real-world problem-solving attitude. The academia's involvement will be extremely critical for a larger "whole of nation" approach. The regulatory authorities have to make way to include higher component of field experimental and project-based learning modules.

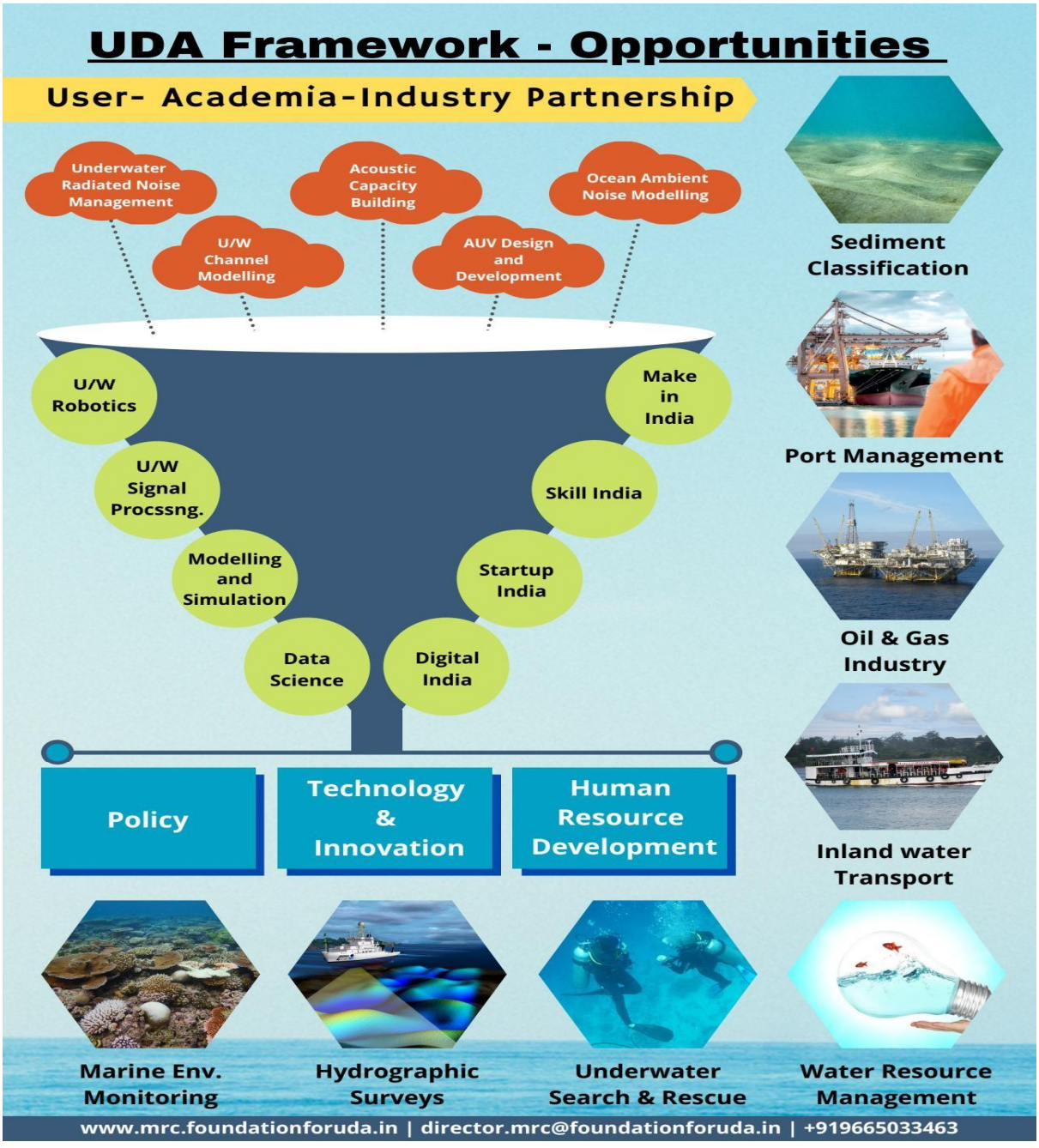


Fig. 4 User-Academia-Industry Partnership for the UDA Framework

The ***New Education Policy*** does have provisions for the same however, precise detailing will have to be undertaken to ensure a seamless User-Academia-Industry partnership at multiple levels and varied aspects. The ***skilling*** will be the biggest initiative to make our youth more employable and establish a direct connect with the industry. Specific skills have to be identified and mapped on to the job description at the industry. Practical and hands-on training will be the key along with precise

parameters to quantify occupational excellence. India can be a major hub for skilling and academic programs for the entire IOR and beyond. The innovation will be a major contributor to drive a program of this scale and dimension. Start-up India initiative is an extremely forward looking program of the Government of India. The UDA framework has to be integrated within the Start-up India initiative. The ***incubation centre*** to drive the UDA framework will have to be derived differently as the innovation ecosystem will be unable to merge with this niche domain easily in the beginning. The academic and skilling programs along with the research programs need to be a prelude to the incubation centre. The ***policy centre*** will have a very significant role to bring this entire initiative into motion. The gaps in every aspect and the inputs from the ground data will be the main drivers for policy interventions. The details of the COE are attached in Enclosure-4.

Hackathons have been a time-tested means of encouraging innovation among the youth and the domain specialists. It also encourages team building and multidisciplinary approach. The Government of India is encouraging innovation in multiple ways and the Smart India Hackathon is one such initiative. ***The UDA Hackathon*** can significantly boost the participation of the young India in nation building for such an unique dimension. The details of the UDA Hackathon are attached in Enclosure-5.

The ***Underwater Archaeology***, in itself has a very broad spectrum of aspects to be addressed to give comprehensive treatment to the subject. Right from the submerged to the now exposed, and also the articles and evidences available in museums and other locations on land. Even the submerged aspect has multiple factors to be addressed including shipwrecks, stone anchors, underwater sites and more. The traditional knowledge can be comprehensively driven with a nuanced Underwater Archaeology initiative.

The underwater domain or any attempt at study, has its unique challenges of accessibility, resource intensive requirement, specialized know how requirement, multi-disciplinary expertise and more. The Archaeology on land no doubt has its challenges, however the underwater aspects elevate the challenges many fold. The sonars that are typically used for underwater surveys has several limitations in the tropical littoral waters of the IOR. Thus, technology or know-how becomes the critical start point along with the platform to carry sonar to the actual location of the site. The multi-disciplinary approach comprising of sonar engineers, acoustic signal processing experts, data science experts etc., need to complement the archaeologist for a meaningful study.

The maritime hubs have been vibrant centres of cultural, civilizational, religious, economic and many more exchanges. Over the years these centres have gained phenomenal prosperity in terms of imbibing best practices, belief systems, know-how and also frameworks for prosperity and harmony to coexist among the diverse aspirational communities and groups. Thus, the study should be able to capture these aspects and then provide intelligent input for strategic formulations for the future. India with its vast coastline and diverse socio-economic and socio-cultural diversity needs to balance the present with the future. A nuanced approach is extremely critical while formulating the way ahead in order to balance multiple competing aspects. Such

studies have had huge relevance in avoiding the same mistakes again and again leading to the few thousand years of a rich legacy we possess.

These studies have their own challenges of managing the multi-dimensional requirements. Right from retaining original information and avoiding any alterations during the course of the study by multiple groups to building a seamless flow of inputs from varied researchers and diverse experts while still being able to build the big picture efficiently. An effective and efficient framework is required to manage such highly challenging and competing requirements. Use of technology to expedite the study ensuring zero adverse impact on the environment and the surroundings has its own unique issues to deal with. Navigation of the existing regulations at the national, regional and global levels with diverse socio-economic and socio-cultural groundings need a deeper understanding to identify gaps and suggest the way ahead. Comparison of similar studies elsewhere globally, will be a source of learning and sharing and research of such studies is of the utmost importance. Traditional knowledge is important to drive any new initiative. Ignoring the past will bring a huge strategic cost along with it, and Underwater Archaeology will be the most important domain to map the modern ways to the traditional understanding that has sustained over a few centuries and has organically developed indigenously. An institutionalized approach is required to map the traditional knowledge to the modern means of S&T.

Conclusion

The UDA framework relates to almost every other domain and thus should be driven in a manner to build synergy across every stakeholder. The political and economic authority is a critical driving force to build any new initiative. There are multiple ministries, agencies and entities with significant stakes in the UDA framework as presented in Enclosure-6. We often find that there is a mismatch between policy authority amongst government agencies in terms of their mandate and the budget allocation for execution of their mandates. The changing geopolitical and geostrategic developments have ensured massive churning in the roles and responsibilities across ministries. India is now at a different level of global standing, politically and economically. Hence, the decision making has to evolve accordingly to match the requirements.

The SAGAR vision of the Honourable Prime Minister needs to be supported by well planned on-ground efforts to realize the strategic vision. The SAGAR vision is an outright maritime construct and given the importance of the underwater domain in the larger MDA formulation, the UDA framework cannot be ignored any further. A strategic vision of this magnitude requires multiple entities at varied levels to synergise and operate together. The apex level and the ground level has to seamlessly coordinate and build structures to have a coherent and nuanced way forward. The varied stakeholders and policy makers at the micro level, need to retain their individual unique characteristics while collaborating with the larger national or regional structures. Such coherent ways cannot be achieved suddenly and have to be evolved over a period of time with a nuanced step by step progression.

The apex level decision making will require the Group of Ministers (GoM) to deliberate on the broader relevance and detailed structure of the entire initiative. The parliamentary standing committee will be required to get inputs on the socio-cultural, socio-economic and socio-political issues at the ground level. A diverse nation like India needs to integrate regional sensitivities and unique characteristics into the larger policy framework. The inputs from the ground level do not come on their own and need to be triggered across varied communities and groups. Thus, a nuanced outreach, engage and sustain campaign will be required. Interactions and debates will have to be triggered and will have to be fed with well-informed inputs. A pool of skilled and knowledgeable human resources will have to be generated across the country in geographically diverse locations and also across multiple strata of the society to manage a more meaningful interaction.

To sustain an initiative of this magnitude, we require institutionalization of the entire skilling & knowledge generation mechanism. The COE as discussed in Enclosure-4 will be an effective and efficient means to build this initiative more comprehensively. The issues to be dealt with are very diverse and require deep involvement of multiple authorities and agencies to drive such efforts. The following COEs are proposed to make sure all the diverse issues are addressed and adequate resources and efforts are apportioned to each of them:

(a) Centre for Coastal Governance.

(b) Centre of Excellence for Sustainable Blue Economy.

(c) Centre of Excellence for Inland Water Transport.

(d) Centre of Excellence for Freshwater Management.

(e) Centre of Excellence for Strategic Security.

(f) Centre of Excellence for Water Dependent Communities.

(g) Centre of Excellence for Underwater Archaeology.

In the initial stages, these centres can operate independently in partnership with certain existing institutes and develop the intellectual muscle as required. No resources should be spent on the civil infrastructure in the initial stages. The centres will be located in geographically diverse locations in the initial stage to make it convenient for the stakeholders and the young students and professionals to join the initiative. Subsequently after three years of operation, we could be planning for an Inter- University Centre (IUC) to build on the institute of global excellence. The detailed structure of the IUC could be deliberated as part of the strategic vision document formulation by the GoM and parliamentary standing committee deliberations. More details on the COEs and their brief details have been included in Enclosure-4.

The UDA framework has a lot to offer but is equally complex to bring synergy across multiple stakeholders and policy makers. Young India has an important stake in an initiative like this and thus, have to be involved right from the beginning. The Hackathon is a time tested means to encourage innovation and crowd sourcing of ideas for building mega initiatives. UDA Hackathon could be started in the lines of the Start-up India initiative.

We have discussed the specific recommendations in Enclosure-7 and have tried to build an effective way forward in order to implement this niche idea as discussed in this interim report. This interim report may be followed up with a detailed **strategic vision document**. While preparing the strategic vision document, the team should have resources to travel and also the authority to interact with the various government agencies and policy makers. Prior to embarking on the strategic vision document, a core team will be required to be set-up so that detailed studies can be undertaken and deep research can be planned while feeding inputs to the GoM and the parliamentary committee. A six month gap can be planned to stabilize the core team for drawing up the outline for the strategic vision document.

MRC is well placed to coordinate the strategic vision formulation along with few nominees from the government agencies to provide critical inputs while formulating the larger strategic vision at the national, regional and global scale. MRC contribution to the UDA framework and the multiple activities initiated to progress the new initiative have been placed in Enclosure-8. A detailed proposal will be submitted once an in principal approval is obtained on the interim report.

Enclosure-1

Underwater Domain Awareness (UDA) Framework

The concept of Underwater Domain Awareness (UDA) in a more specific sense will translate to our eagerness to know what is happening in the underwater realm of our maritime areas and the freshwater systems. This keenness for underwater awareness from the security perspective, means defending our Sea Lines of Communication (SLOC), coastal waters and varied maritime assets against the proliferation of submarines and mine capabilities intended to limit the access to the seas and littoral waters. The freshwater systems are not defended by the Navy & the Coast Guard, but these waters are equally vulnerable and more complex to manage. However, just the military requirement may not be the only motivation to generate underwater domain awareness. The earth's underwater geophysical activities have a lot of relevance to the wellbeing of the human kind and monitoring of such activities could provide vital clues to minimize the impact of devastating natural calamities. The commercial activities in the underwater realm need precise inputs on the availability of resources to be able to effectively and efficiently explore and exploit them for economic gains. The regulators on the other hand need to know the pattern of exploitation to manage a sustainable plan. With so many activities, commercial as well as military, there is significant impact on the environment. Any conservation initiative needs to precisely estimate the habitat degradation and species vulnerability caused by these activities and assess the ecosystem status. The scientific and the research community need to engage and continuously update our knowledge and access of the multiple aspects of the underwater domain. The figure below, presents a comprehensive perspective of the UDA. The underlying requirement for all the stakeholders is to know the developments in the undersea domain, make sense out of these developments and then respond effectively and efficiently to them before they take shape of an event.

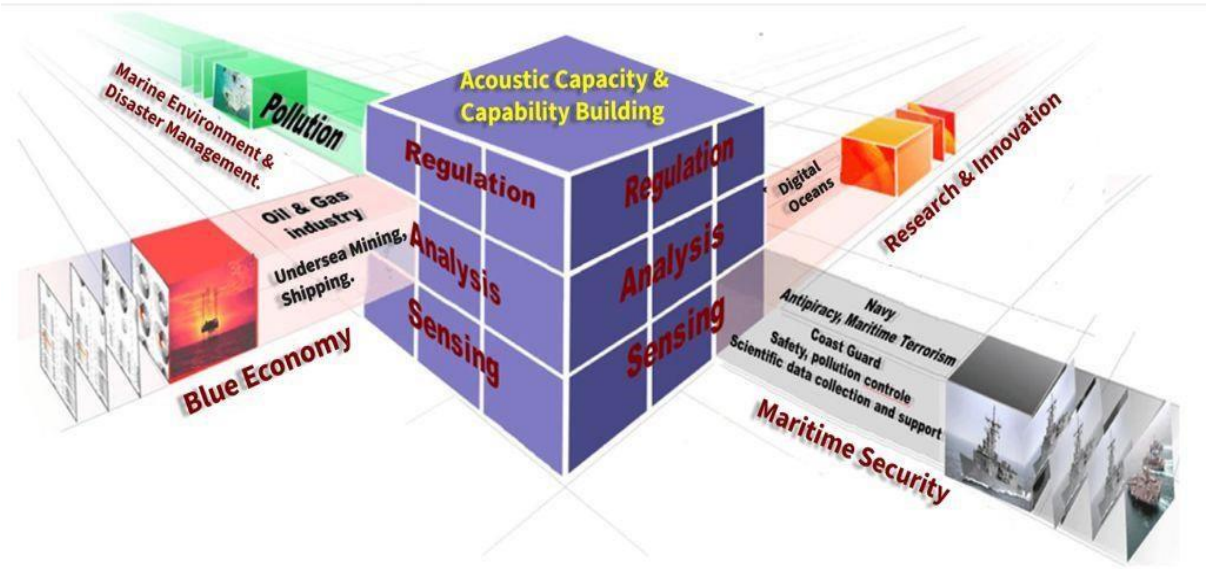


Fig. Comprehensive Perspective of Underwater Domain Awareness

The UDA on a comprehensive scale, needs to be understood in its horizontal and vertical construct. The horizontal construct would be the resource availability in terms

of technology, infrastructure, capability and capacity specific to the stakeholders or otherwise. The stakeholders represented by the four faces of the cube will have their specific requirements, however the core will remain the acoustic capacity and capability. The vertical construct is the hierarchy of establishing a comprehensive UDA. The first level or the ground level would be the sensing of the undersea domain for threats, resources and activities. The second level would be making sense of the data generated to plan security strategies, conservation plans and resource utilization plans. The next level would be to formulate and monitor regulatory framework at the local, national and global level.

The figure above gives a comprehensive way forward for the stakeholders to engage and interact. The individual cubes represent specific aspects that need to be addressed. The User-Academia-Industry partnership can be seamlessly formulated based on the user requirement, academic inputs and the industry interface represented by the specific cube. It will enable a more focused approach and a well-defined interactive framework. Given the appropriate impetus, the UDA framework can address multiple challenges being faced by the nation today. Meaningful engagement of Young India for Nation Building probably is the most critical aspect that deserves attention. Multi-disciplinary and multi-functional entities can interact and contribute to seamlessly synergize their efforts towards a larger goal.

The UDA Framework as proposed above has been formulated jointly by the Maritime Research Centre (MRC), Pune and M/S NirDhwani Technology Pvt Ltd (NDT). The focus is on all the three aspects namely Policy, Technology & Innovation and Human Resource Development. More details are available in the MRC website http://foundationforuda.in/mrc/.

Enclosure-2

Acoustic Dimension of the UDA Framework

The impact of the tropical littoral underwater medium will be significant and could undermine the received signal at the receiver. One interesting example is in order to explain the impact of ***biological noise*** in the IOR. In 1988, India deployed it first Nuclear Submarine, the INS Chakra on an operational mission off the east coast in Visakhapatnam. The boat sat down in position to detect the incoming fleet as per the instructions for the exercise. Within sometime the sonar screen got completely blanked out and the boat was blinded. The crew got together for a brain storming session and it was suggested that a blast sonar transmission will do the trick (transmission for a submarine during operational mission is suicidal as it will reveal its position). They carried out high power sonar transmission and it worked. The Captain of the boat, later wrote in a blog that it was possibly because of ***Snapping Shrimps***. Just to remind the reader, in 1946 the Scripps Institute of Oceanography in the US, undertook a detailed Snapping Shrimp mapping for the entire world in preparation for the launch of their first Nuclear Submarine, Nautilus in 1952. It was revealed in that study, that the tropical waters are the habitat for Snapping Shrimps. The Indo-Pacific nations are aggressively going for submarine acquisition lately, and this example will have some value for them. Acquiring high value military hardware at the behest of extra-regional powers may not solve our problems. ***UDA has multiple acoustic dimensions*** and we need to understand it comprehensively.

The shipping traffic globally has been increasing at an alarming rate. The shipping sector being the engines of economic growth globally, in terms of transporting 90% of trade by volume, generates least political will, to contain the noise underwater. The increasing shipping traffic has its own impact on the low frequency ambient noise in the region. This rise in ambient noise has two fold implications on sonar performance, due to deteriorating Signal to Noise Ratio (SNR) and also changing migration pattern for the marine mammals that will affect biological noise patterns. With increasing submarine fleets and a requirement to deploy them effectively, the SNR and the Snapping Shrimp beds is a major factor that deserves attention. Ambient noise assessment is a critical requirement that cannot be imported, but will require indigenous efforts involving field work. The frequent big whale stranding being observed in the IOR is a manifestation of the severe ***Acoustic Habitat Degradation*** due to unregulated maritime activities and also absence of proper ***Environment Impact Assessment (EIA)*** while planning mega development projects in the maritime sector. MRC has investigated a few of the recent big whale stranding's and attributed them to the anti-piracy operations and increasing shipping traffic. The so called developmental plans need to be more nuanced and backed with comprehensive EIA. Security and growth are interconnected as stated in the SAGAR vision and need to be dealt with comprehensively. We will have to look at the ecosystem challenges of ensuring effective implementation of SAGAR.

The increasing maritime activities are also accompanied by higher noise levels in the ocean. Acoustic signals or sound waves being the only signal that propagate efficiently underwater also means that the marine species use sound for multiple biologically

critical functions like foraging, navigation, communication, finding mates and more. Thus, increasing noise in their habitat interferes with their ability to perceive the environment around them, thereby causing acoustic habitat degradation. The frequent stranding of marine mammals along the Indian coast is a manifestation of the catastrophic acoustic habitat degradation. Figure below, presents recent incidents of stranding that is manifestation of the severe acoustic habitat degradation. Such stranding's are attributable to the navigation failure due to high ambient noise leading to disorientation.

Fig. Recent Marine Mammal Stranding along the Indian Coast.
Left: 42 ft Blue Whale Stranding off the Alibaug Coast in Jun 2015.
Centre: 50 ft Bryde Whale Stranding off the Mumbai Coast in Jan 2016.
Right: Over 90 Short-Finned Pilot Whales Stranding off Tuticorin Beach in Jan 2016.

The MH-370 accident and the subsequent search operation was another geopolitical exercise to corner China and its Acoustic capability and capacity development initiative by the west. The MH-370 had more than 90 % Chinese people and China was very keen to lead the search operation in the IOR, however the west assigned the role to Australia (a member of the QUAD), which potentially had no direct stake in the event. The massive acoustic capacity and capability development that happened during the three year search operations and global funding was denied to the Chinese. The deployment of AUVs for the search required a one year effort for high resolution undersea mapping. The IOR requires massive effort to generate such maps for varied application including military and non-military.

Enclosure-3

Skill Development for Varied Application in the Indian Ocean Region (IOR)

1. ACOUSTIC SURVEY

The acoustic survey is required for multiple industries and with the recent initiatives of the Government of India on maritime and inland water transport, mega opportunities have been created. A hierarchical human resource development program will be required to map the skill requirements at multiple levels and the job profiles to build the domain effectively.

Potential Opportunities

The acoustic survey is required for multiple applications in the maritime domain, water resource management and inland water transport. The underwater sensing will have varied applications as follows:

a) Sediment Classification
   (i) Ensuring effective dredging for innumerable applications like maintaining navigable waterways, water resource management in freshwater systems like lakes & reservoirs and more.
   (ii) Study of siltation process for prevention.
   (iii) Disposal plan for the removed silt.

b) Port Management.
   (i) Security from underwater intrusion.
   (ii) Marine environmental monitoring.
   (iii) Ensuring navigational safety at all times.
   (iv) Marine eco-system monitoring for formulation of sustainable growth model.

(c) Oil & Gas Industry.
   (i) Seismic survey.
   (ii) Security of offshore assets.
   (iii) Environmental impact assessment due to their activities.
   (iv)Aid to R&D

(d) Inland Water Transport.
   (i) Navigational safety.
   (ii) Environmental impact assessment.
   (iii) Security.
   (v) Surveys to optimally pack multiple activities.

(e) Water Resource Management.
   (i) Capacity building for storage dams.
   (ii) Ensuring effectiveness of recharge systems.
   (iii) Effective de-siltation plan.
   (iv) Prevention of siltation.

(f) Underwater Search and Recovery.
(g) Shipping industry has excessive use of acoustic surveys for almost every activity at sea.
(h) Undersea mining has become very critical and acoustic survey is the first step.
(i) Hydrographic surveys are critical for multiple applications in the maritime domain and the freshwater systems.
(j) Acoustic Habitat Degradation could become the next big blue economic concern and needs effective monitoring and mitigation.

Industry Connect

Multiple industries will be relevant to take this domain forward. Technician to data logger, data analyst and research staff are multiple levels of opportunities that will be open to the participants. The program could also support training requirements of the stakeholders in the maritime sector, in addition to the skilling of fresh applicants for such jobs. The following are the clear job-opportunities:

a. Oil & Gas Industries and the supporting agencies will have a huge requirement of such trained people.
b. Undersea survey companies for mining and undersea mapping.
c. Governmental regulators in the maritime sector.
d. NGOs involved in marine environmental monitoring.
e. Consultants involved in Environmental Impact Assessment
f. Irrigation departments across states and the supporting agencies.
g. Flood control department and supporting agencies.
h. Shipping industry and port authorities.
i. Scientific organizations and R&D groups.
j. Policy makers.
k. Maritime security agencies.

Job Description
The domain is huge with substantial hierarchical opportunities. The entire program has been divided into following levels:

(a) Technicians for operations, maintenance and repair of the instrumentation.
(b) Deployment Crew.
(c) Data Logger.
(d) Data Analyst.

Required Qualification
The entry level qualifications for the participants are as follows:
(a) Technicians for operations, maintenance and repair of the instrumentation.
- ITI qualified with science background.
- Higher secondary with good grades and science background.

(b) Deployment crew.
- ITI qualified with science background.
- Higher secondary with good grades and science background

(c) Data Logger.
- ITI qualified with science background.
- Higher secondary with good grades and science background.

(d) Data Analyst.

- Bachelor of Science.
- Bachelor of Computer Application.
- Bachelor of Technology with specialization in:
    - o Electrical/Electronics.
    - o Computer Science.
    - o Information Technology.
    - o Instrumentation.

Course Curriculum

The entire course curriculum has been placed at enclosure - 3.1

Broad Structure

Sr. No.	Job Description	Program	Duration	Qualification	Remarks
1.	Technician	Diploma in Vocation (Acoustic Survey Instrumentation)	72 weeks (2 semesters)	Higher secondary with good grades and science background.	The diploma candidate will have skills for operations and maintenance, while the post diploma certificate holder will be able to repair as well.
		Post Diploma Certificate Program in Acoustic Survey Instrumentation	72 weeks (2 semesters)	ITI qualified with science background.	
2.	Deployment crew	Diploma in Vocation (Waterfront Field Deployment)	72 Weeks (two semester)	Higher secondary with good grades and science background.	The diploma candidate will have skills for deployment, while the post diploma certificate holder will be able to do the job as a repair technician and deployment crew.
		Post Diploma Certificate Program in Waterfront Field Deployment	144 Weeks (Four semester)	ITI qualified with science background.	
3.	Data Logger	Diploma in Vocation (Acoustic Survey Data Logger)	72 weeks (2 semesters)	Higher secondary with good grades and science background.	The diploma candidate will have skills for data logging, while the post diploma certificate holder will be able to do the job as a repair technician and data logger.
		Post Diploma Certificate Program in Acoustic Survey Data Logging	144 weeks (4 semesters)	ITI qualified with science background.	
4.	Data Analyst	Post Graduate Diploma in Acoustic Survey Data Analytics	72 weeks (2 semesters)	Bachelor in Science/ Technology	Data Analytics during field experiment at the water front.

Infrastructure Requirement

The infrastructure required for the program as per the course curriculum is as follows:

(a) Classroom Facility for conduct of the lectures and interactions The existing facility at the institute can be used to start with. The multipurpose classroom facility with provisions for lectures, demonstrations, interactions and limited hands-on activities could be planned. Also the multiple levels of the program can be handled based on the curriculum requirements in the same classroom.

(b) Basic Electronic Laboratory The basics of electronics with practical classes and hands-on exposure will require a dedicated facility. The same can be shared with other programs as well having common curriculum. Initially, it could also be accessed from other Engineering Institutes under a structured MoU.

(c) Virtual Classroom with Simulation Tools The specialized acoustic survey tools will require substantial exposure for the trainees to get a good understanding of their functioning and look & feel. The trainees should be familiar with these equipment's before they go for the field experiment and hands-on exposure. Simulation tools have become the de-facto training aid to bridge this gap.

(d) Computer Laboratory with Internet Facility The trainees need to get exposed to self-learning and project based thinking skill development. This will also allow certain non-contact training hours for the program. The computer lab with internet connectivity will be a critical infrastructure required for this purpose.

(e) Field Experimental Facility The trainees need to get exposure to field experimental real-time data gathering and analysis. This will be a very critical component of the hands-on training experience for building their confidence to handle such high-end equipment independently. The wide variety of sonars and acoustic survey equipment that these trainees will potentially handle in their professional life will be extremely expensive to have in our own inventory. There are equipment hiring firms that can be taken on-board to have an optimum training infrastructure plan. MRC/NDT has undertaken field experimental workshops at the Khadkwasla lake with four different equipment hired at very nominal cost.

(f) Access to High-end Research Literature The upper two levels will require access to high-end research literature to keep them abreast with the state-of-the-art technology and research updates. MRC will provide that access from its own resources to manage the program. Research fellows at MRC can engage with the trainees to support their project formulation and execution.

(g) Computing Laboratory with High Performance Computing (HPC) Infrastructure The upper two levels of Data Analysts and Research Staff should be able to code and build their own algorithms for data processing and analysis. This will require appropriate computing infrastructure to be able to get exposed to the state-of-the-art technology available today. Many of the algorithms today demand a certain level of computing capability for their execution. Some basic HPC infrastructure will be required to start with, within our own premises and the more advance infrastructure can be accessed with shared resources from other organizations.

2. UNDERWATER BIOTECHNOLOGY

The rapid growth of genetic, cellular and molecular technologies is enabling scientists to explore and develop marine resources for widespread applications in the food, medical, pharmaceutical, environmental and energy industries. With the recent initiatives of the Government of India on maritime sector, mega opportunities have been created for Blue Biotechnology. A hierarchical human resource development program will be required to map the skill requirements at multiple levels and the job profiles to build the domain effectively.

Potential Opportunities

These oceans have rich biodiversity and potential resources which we are only beginning to explore. There has been increasing development and research in focused areas of Marine Biotechnology to develop novel processes and products aiming at enhancement of marine biotech industrial processes, biomedical material development, environment management and intensive aquaculture production.

(i) Food Industry: Aquaculture production, innovation, food additives
(ii) Bioenergy: Biofuels & Bio refiners
(iii) Industrial production: Marine biopolymers/enzymes/biomaterials for food cosmetics and health
(iv) Environment: Biosensing technology for environment monitoring, bio stimulation, bioaugmentation
(v) Marine Biology and relevant research on animal behavior, diseases, etc.

The Honourable Prime Minister has announced the SAGAR (Security And Growth for All in the Region) vision and multiple initiatives to support the same, including Sagarmala, Bharatmala, Inland Water Transport and more. These are all mega projects with massive fund allocation. Underwater Biotechnology will be the single most important skill requirement, cutting across multiple applications as detailed above. Adequately skilled human resource will be the key.

Industry Connect

Multiple industries will be relevant to take this domain forward. Technician to data logger, data analyst and research staff are multiple levels of opportunities that will be open to the participants. The program could also support training requirements of the stakeholders in the maritime sector, in addition to the skilling of fresh applicants for such jobs. The following are the clear job-opportunities:

a) Food Industry: Aquaculture production, innovation, food additives
b) Bioenergy: Biofuels & Bio refiners
c) Industrial production: Marine biopolymers/enzymes/biomaterials for food cosmetics and health
d) Environment: Biosensing technology for environment monitoring, bio stimulation, bioaugmentation
e) Marine Biology and relevant research on animal behavior, diseases
f) Oil & Gas Industries and the supporting agencies will have a huge requirement of such trained people.
g) Undersea survey companies for mining and undersea mapping.
h) Governmental regulators in the maritime sector.
i) NGOs involved in marine environmental monitoring.
j) Consultants involved in Environmental Impact Assessment.
k) Irrigation departments across states and the supporting agencies.

l) Flood control department and supporting agencies.
m) Scientific organizations and R&D groups.
n) Policy makers.
o) Maritime security agencies.

Program Objectives

The aim of the program is to encourage capacity building to address the challenges encountered by the underwater biotechnological domain. To ignite young talented minds having strong foundation in science to take up major challenges which human race faces and to find practical solutions through marine biotechnological interventions.

The key areas of focus include:

1) Optimizing marine bioprospecting and utilization of marine resources for industrial purposes through sustainable techniques.
2) Identifying innovative strategies to boost production of renewable bioenergy and reorganization of bioresources.
3) Acknowledging underwater climate change and cultivating economically feasible environmental biomonitoring systems to curb anthropogenic disturbances in the underwater domain.
4) Augmenting aquatic food production for commercial and economical purposes and facilitating innovation in the marine food industry.

The program is focused on training the required skill and aptitude in marine based biotechnologies to enable employability in the public sector and private industries at national as well as international level. The program will also provide a platform for students to gain insight into the industry demands and interact with relevant professionals. Through this program, students will additionally develop knowledge implementation skills, communication skills and establish a mindset for collaborative work.

Job Description

The domain is huge with substantial hierarchical opportunities. The entire program has been divided into following levels:

(a) Technicians for operations, maintenance and repair of the instrumentation.

(c) Data Logger.

(d) Data Analyst.

(e) Occupational health &safety coordinator

(f) Environmental & Impact Assessment Specialist

Required Qualification

The entry level qualifications for the participants is as follows:

a) Technicians for operations, maintenance and repair of the instrumentation.
   - ITI qualified with science background.
   - Higher secondary with good grades and science background

b) Data Logger.
   - ITI qualified with science background.

- Higher secondary with good grades and science background.

c) Data Analyst.
   - Bachelor of Science.
   - Bachelor of Computer Application.
   - Bachelor of Technology with specialization in:
     - Electrical/Electronics.
     - Computer Science.
     - Information Technology.
     - Instrumentation.

d) Occupational health & safety coordinator
   - Bachelor of Science/Technology

e) Environmental & Impact Assessment Specialist
   - Bachelor of Science/Technology

Course Curriculum

The entire course curriculum has been placed at enclosure – 3.2

Sr. No.	Job Description	Program	Duration	Qualification	Remarks
1.	Technician	Diploma of Vocation (D.Voc) in Biotech Instrumentation	72 weeks (2 semesters)	Higher secondary with good grades and science background.	The diploma candidate will have skills for operations and maintenance, while the post diploma certificate holder will be able to repair as well.
		Post Diploma Certificate Program in Biotech Instrumentation	72 weeks (2 semesters)	ITI qualified with science background.	
2.	Data Logger	Diploma of Vocation (UW Biotechnology Data Logger)	72 weeks (2 semesters)	Higher secondary with good grades and science background.	The diploma candidate will have skills for data logging, while the post diploma certificate holder will be able to do the job as a repair technician and data logger.
		Post Diploma Certificate Program (UW Biotechnology Data Logger)	144 weeks (4 semesters)	ITI qualified with science background.	
3.	Data Analyst	Post Graduate Diploma (UW Biotech Data Analytics)	72 weeks (2 semesters)	Bachelor in Science/ Technology	Data Analytics during field experiment.
4.	Occupational health &safety coordinator	Post Graduate Diploma in UW Occupational Safety	72 weeks (2 semesters)	Bachelor in Science/ Technology	Assessment of and adherence to occupational health & safety measures during field experiments.

5.	Environmental & Impact Assessment Specialist	Post Graduate Diploma in UW Environmental & Impact Assessment	72 weeks (2 semesters)	Bachelor in Science/ Technology	Assessment of marine environment and impact of anthropogenic activities for various purposes.

Infrastructure Requirement

The infrastructure required for the program as per the course curriculum is as follows:

(a) Classroom Facility for conduct of the lectures and interactions: The existing facility at the institute can be used to start with. The multipurpose classroom facility with provisions for lectures, demonstrations, interactions and limited hands-on activities could be planned. Also, the multiple levels of the program can be handled based on the curriculum requirements in the same classroom.

(b) Laboratory: The basics of laboratories for caring out experiments with hands-on exposure will require a dedicated facility. The same can be shared with other programs as well having common curriculum.

(c) Virtual Classroom with Simulation Tools: The specialized tools will require substantial exposure for the students to get a good understanding of their functioning and look & feel. They should be familiar with these equipment's before they go for the field experiment and hands-on exposure. Simulation tools have become the de-facto training aid to bridge this gap.

(d) Computer Laboratory with Internet Facility: The students need to get exposed to self-learning and project-based thinking skill development. This will also allow certain non-contact training hours for the program. The computer lab with internet connectivity will be a critical infrastructure required for this purpose

(e) Field Experimental Facility: students need to get exposure to fieldexperimental real-time data gathering and analysis. This will be a very criticalcomponent of the hands-on training experience for building their confidence to handlesuch high-end equipment independently. There are equipment hiringfirms that can be taken on-board to have an optimum training infrastructure plan.MRC/NDT has undertaken field experimental workshops at the Khadkwasla lake withfour different equipment hired at very nominal cost.

(f) Access to High-end Research Literature The upper two levels will require access to high-end research literature to keep them abreast with the state-of-the-art technology and research updates. MRC will provide that access from its own resources to manage the program. Research fellows at MRC can engage with the trainees to support their project formulation and execution.

(g) Computing Laboratory with High Performance Computing (HPC) Infrastructure: The upper two levels of Data Analysts and Research Staff should be able to code and build their own algorithms for data processing and analysis. This will

require appropriate computing infrastructure to be able to get exposed to the state-of-the-art technology available today. Many of the algorithms today demand a certain level of computing capability for their execution. Some basic HPC infrastructure will be required to start with, within our own premises and the more advance infrastructure can be accessed with shared resources from other organizations.

3. ARTIFICIAL INTEIGENCE AND ROBOTICS

Underwater robotics and artificial intelligence are a promising sector in the context of advancing marine and maritime science and its technological applications. AI and Robotics enable innovations in far reaching sea exploration, autonomous and deep-sea robots, teleoperations and many more. It aims to shape skills for implementation of autonomous marine and underwater robots with remote operating capabilities, and in the use of artificial intelligence in these fields.

Potential Opportunities

Modern robotics is spreading across almost all sectors, including the maritime industry. AI and robotics have a promising career in the offshore oil and gas, renewable, search and recovery, naval and maritime sectors.

1. Autonomous Underwater Vehicles (AUVs) play a key role in Underwater Search and Recovery.
2. An autonomous surface vehicle (ASV) model system for the surveillance of marine areas by detecting and recognizing vessels through artificial intelligence (AI)-based image recognition services, in search of those carrying out illegal activities
3. Unmanned surface vehicles (USVs) are the main investigation areas of maritime autonomous surface ships (MASSs), for surveillance, research, scientific investigation, security, etc.
4. Shipping industry has excessive use of Robotics for almost every activity at sea.
5. Undersea mining has become very critical and AI and Robotics is the first step. The future undersea mining will take place in greater depths and with a complexity of machines that require support from robotic systems equipped with a substantial amount of artificial intelligence.
6. Disaster Management: AI and Robotics play a vital role in disaster research by replacing response teams in remote and hazardous areas or by carrying out long-term monitoring.
7. USV and AUV multi-vehicle collaborative navigation has also been tested in the underwater detection of hydrocarbons and oil spill surveys. Through detailed maps and satellite navigation, an ASV can detect and avoid static obstacles.
8. To ensure accurate detection and tracking of objects at sea.
9. For Surveillance in Marine Protected Areas.
10. Autonomous vehicles and robotics not only in shipyards and ports, but also as aids for sea transport services.
11. Artificial intelligence (AI); applications of this technology in combination with big data help in detecting and capturing information coming from ship sensors.

12. Virtual, augmented and mixed reality (VR); tools are expected to be a part of any vessel equipment.
13. The internet of things; today all ships and maritime artifacts are mega-cities, fully-equipped with sensors.
14. Digital security; digitalization demands stronger security tools and processes.
15. 3D printing and additive engineering (3DP); they improve Shipping maintenance processes.
16. Hydrographic surveys are critical for multiple applications in the maritime domain and the freshwater systems.
17. Acoustic Habitat Degradation could become the next big blue economic concern and needs effective monitoring and mitigation.

The Honourable Prime Minister has announced the SAGAR (Security And Growth for All in the Region) vision and multiple initiatives to support the same, including Sagarmala, Bharatmala, Inland Water Transport and more. These are all mega projects with massive fund allocation. Acoustic survey will be the single most important skill requirement, cutting across multiple applications as detailed above. Adequately skilled human resource will be the key.

Industrial Connect

Multiple industries will be relevant to take this domain forward. Technician to data logger, data analyst and research staff are multiple levels of opportunities that will be open to the participants. The program could also support training requirements of the stakeholders in the maritime sector, in addition to the skilling of fresh applicants for such jobs. The following are the clear job-opportunities:

(a) Oil & Gas Industries and the supporting agencies will have a huge requirement of such trained people.
(b) Undersea survey companies for mining and undersea mapping. Hydrographic surveys are critical for multiple applications in the maritime domain and the freshwater systems.
(c) Shipping industry has excessive use of Robotics for almost every activity at sea.
(d) Undersea mining has become very critical and AI and Robotics
(e) Disaster mitigation and control authorities.
(f) Digital security; digitalization demands stronger security tools and processes.
(g) 3D printing and additive industries for improved Shipping maintenance processes.
(h) Governmental regulators in the maritime sector.
(i) Marine Transport regulation Authorities: Autonomous vehicles and robotics not only in shipyards and ports, but also as aids for sea transport services.
(j) Consultants involved in Environmental Impact Assessment.
(k) NGOs involved in marine environmental monitoring. Underwater detection of hydrocarbons and oil spill surveys through detailed maps and satellite navigation.

Job Description

The domain is huge with substantial hierarchical opportunities. The entire program has been divided into five levels:

a. Technicians for operations, maintenance and repair of the instrumentation.
b. Data Logger.
c. Data Analyst.
d. Applied MachineLearning engineer.
e. Applied Automation andRobotics engineer

Required Qualification

The entry level qualifications for the participants is as follows:

a. Technicians for operations, maintenance and repair of the instrumentation.
    - ITI qualified with science background.
    - Higher secondary with good grades and science background.
b. Data Logger.
    - ITI qualified with science background.
    - Higher secondary with good grades and science background
c. Data Analyst.
    - Bachelor of Science.
    - Bachelor of Computer Application.
    - Bachelor of Technology with specialization in:
        - Electrical/Electronics.
        - Computer Science.
        - Information Technology.
        - Instrumentation.
f. Applied MachineLearning engineer.
    - BSc Mathematics/ BSc Computer Science or B.E / BTech
d. Applied Automation andRobotics engineer
    - BSc Mathematics/ BSc Computer Science or B.E / BTech

Course Curriculum

The entire course curriculum has been placed at enclosure - 3.3

Sr. No	Job Description	Program	Duration	Qualification	Remarks
1.	Technician	Diploma of Vocation (D.Voc) in Automation and Robotics	72 weeks (2 semesters)	ITI qualified with Computer Science background.	The diploma candidatewill have skills for operations and maintenance, while thepost diploma certificateholder will be able to repair as well.
		Post Diploma Certificate Program in Automation and Robotics	72 weeks (2 semesters)	Diploma in Engineering with a background in Mathematics and Computer Science	

2.	Data Logger	Diploma of Vocation (Data Management)	72 weeks (2 semesters)	ITI qualifiedwith Computer Science background.	The diploma candidatewill have skills for datalogging, while the post diploma certificate holder will be able to do the job as a repair technician and data logger.
		Post Diploma Certificate Program (Data Management)	144 weeks (4 semesters)	Diploma in Engineering with a background in Mathematics and Computer Science.	
3.	Data Analyst	Post Graduate Diploma (Big Data Analytics)	72 weeks (2 semesters)	BSc Mathematics / BSc Computer Science or B.E / BTech	Data Analytics duringfield experiment.
4.	Applied Machine Learning engineer	Post Graduate Diploma in Machine Learning applications	72 weeks (2 semesters)	BSc Mathematics / BSc Computer Science or B.E / BTech	Build pipelines and applications centredaround Machine Learning algorithms
5.	Applied Automation and Robotics engineer	Post Graduate Diploma in Advanced Robotics	72 weeks (2 semesters)	BSc Mathematics / BSc Computer Science or B.E / BTech	Design and Development of UWRobot Prototypes for UDA related Field Experiments

Infrastructure Requirement

The infrastructure required for the program as per the course curriculum is as follows:

(a) Classroom Facility for conduct of the lectures and interactions: The existing facility at the institute can be used to start with. The multipurpose classroom facility with provisions for lectures, demonstrations, interactions and limited hands-on activities could be planned. Also, the multiple levels of the program can be handled based on the curriculum requirements in the same classroom.

(b) Laboratory: The basics of laboratories for caring out experiments with hands-on exposure will require a dedicated facility. The same can be shared with other programs as well having common curriculum.

(c) Virtual Classroom with Simulation Tools: The specialized tools will require substantial exposure for the students to get a good understanding of their functioning and look & feel. They should be familiar with these equipment's before they go for the field experiment and hands-on exposure. Simulation tools have become the de-facto training aid to bridge this gap.

(d) Computer Laboratory with Internet Facility: The students need to get exposed to self-learning and project-based thinking skill development. This will also allow certain non-contact training hours for the program. The computer lab with internet connectivity will be a critical infrastructure required for this purpose

(e) Field Experimental Facility: students need to get exposure to fieldexperimental real-time data gathering and analysis. This will be a very criticalcomponent of the hands-on training experience for building their confidence to handlesuch high-end equipment independently. There are equipment hiringfirms that can be taken on-board to have an optimum training infrastructure plan.MRC/NDT has undertaken field experimental workshops at the Khadkwasla lake withfour different equipment hired at very nominal cost.

(f) Access to High-end Research Literature The upper two levels will require access to high-end research literature to keep them abreast with the state-of-the-art technology and research updates. MRC will provide that access from its own resources to manage the program. Research fellows at MRC can engage with the trainees to support their project formulation and execution.

(g) Computing Laboratory with High Performance Computing (HPC) Infrastructure: The upper two levels of Data Analysts and Research Staff should be able to code and build their own algorithms for data processing and analysis. This will require appropriate computing infrastructure to be able to get exposed to the state-of-the-art technology available today. Many of the algorithms today demand a certain level of computing capability for their execution. Some basic HPC infrastructure will be required to start with, within our own premises and the more advance infrastructure can be accessed with shared resources from other organizations.

Enclosure-3.1

Course Curriculum – Acoustic Survey

The entire curriculum has been designed to meet the job description mentioned above.

S. No.	Program Description	Course	Module	Theory/ Practical Hours	No. of Credits
1(a)	Diploma in Vocation (Acoustic Survey Instrumentation)	Instrumentation	Types of Sonars and sensors	45/30	4
		Operations	Types of Sonars and sensors	30/45	4
		Maintenance/ Repair	Basic Electronics	45/30	4
			Test Equipment's	45/30	4
			Planned Preventive Maintenance	45/30	4
			Circuit Tracing	30/45	4
			PCB Basics	30/45	4
		Field Visit	Industry Visit	90	6
			Apprentice-ship	90	6
			Project	90	6
1(b)	Post Diploma Certificate Program in Acoustic Survey Instrumentation	Instrumentation	Types of Sonars and sensors	45/30	4
		Operations	Types of Sonars and sensors	30/45	4
		Maintenance/ Repair	PCB Basics	45/30	4
			Circuit Theory	45/30	4
			Planned Preventive Maintenance	45/30	4
			Circuit Tracing	30/45	4
			PCB Repairs	30/45	4
		Field Visit	Industry Visit	90	6
			Apprentice-ship	90	6
			Project	90	6
2(a)	Diploma in Vocation (Waterfront Field Deployment)	Seamanship	Basics of Seamanship	30/45	4
			Rope work	45/30	4
			Communication and Signalling	45/30	4
			Watch Keeping and Terminologies	30/45	4
		Instrumentation	Types of Sonars and Sensors	45/30	4
		Operations	Types of Sonars	30/45	4

			and Sensors		
		Field Visit	Industry Visit	180	12
			Apprentice-ship	180	12
2(b)	Post Diploma Certificate Program in Waterfront Field Deployment	Seamanship	Basics of Seamanship	30/45	4
			Rope work	45/30	4
			Communication and Signalling	45/30	4
			Watch Keeping and Terminologies	30/45	4
		Instrumentation	Types of Sonars and Sensors	45/30	4
		Operations	Types of Sonars and Sensors	30/45	4
		Maintenance/ Repair	PCB Basics	45/30	4
			Circuit Theory	45/30	4
			Planned Preventive Maintenance	45/30	4
			Circuit Tracing	30/45	4
			PCB Repairs	30/45	4
		Field Visit	Industry Visit	180	12
			Apprentice-ship	240	15
			Project	360	24
3(a)	Diploma in Vocation (Acoustic Survey Data Logger)	Instrumentation	Types of Sonars and Sensors	45/30	4
		Operations	Types of Sonars and Sensors	30/45	4
		Data Formats	Data Types	30/45	4
			Data Handling Tools	30/45	4
		Data Acquisition Systems	Signals & Systems	45	3
			Hardware	45	3
			Lab VIEW	30	2
		Storage Devices	Storage Media	30	2
			Data Read & Write	30	2
			File Management	30	2
		Field Work	Industry Visit	90	6
			Apprentice-ship	90	6
			Project	90	6
3(b)	Post Diploma Certificate	Instrumentation	Types of Sonars and Sensors	45/30	4

	Program in Acoustic Survey Data Logging	Operations	Types of Sonars and Sensors	30/45	4
		Data Formats	Data Types	30/45	4
			Data Handling Tools	30/45	4
		Data Acquisition Systems	Signals & Systems	45	3
			Hardware	45	3
			Lab VIEW	30	2
		Storage Devices	Storage Media	30	2
			Data Read & Write	30	2
			File Management	30	2
		Maintenance/ Repair	PCB Basics	45/30	4
			Circuit Theory	45/30	4
			Planned Preventive Maintenance	45/30	4
			Circuit Tracing	30/45	4
			PCB Repairs	30/45	4
		Field Work	Industry Visit	180	12
			Apprentice-ship	180	12
			Project	360	24
4.	Post Graduate Diploma in Acoustic Survey Data Analytics	Instrumentation	Types of Sonars and Sensors	45/30	4
		Operations	Types of Sonars and Sensors	30/45	4
		Underwater Acoustics	Ambient Noise	45	3
			Underwater Propagation	45	3
		Coding	Matlab/ Python	45/30	4
		Introduction toData Analytics	Statistics	45	3
			Machine Learning	45	3
			Data Visualization	45	3
		Field Work	Industry Visit	90	6
			Project	270	18

Enclosure - 3.2

Course Curriculum – Underwater Biotechnology

The entire curriculum has been designed to meet the job description mentioned above.

Sr. No.	Program Description	Course	Module	Theory/ Practical Hours	No. of Credits
1 (a)	Diploma of Vocation (D.Voc) (Biotech Instrumentation)	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Maintenance/ Repair	Basics of Electronics & Electrical Technology	45/30	4
			Sensors & Transducers	30/45	4
			Planned Preventive Maintenance	45/30	4
			Circuit Tracing & PCB Basics	30/45	4
			Valves & Actuators	45/30	4
		Field Visit	Industry Visit	90	6
			Apprenticeship	90	6
			Project	90	6
1 (b)	Post Diploma Certificate Program in Biotech Instrumentation	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Maintenance/ Repair	Basics of Electronics & Electrical Technology	45/30	4
			Sensors & Transducers	30/45	4
			Planned Preventive Maintenance	45/30	4
			Circuit Tracing & PCB Basics	30/45	4
			Valves & Actuators	45/30	4
		Field Visit	Industry Visit	90	6
			Apprenticeship	90	6
			Project	90	6
2 (a)	Diploma of Vocation (UW Biotechnology Data Logger)	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Data Formats	Data Types	30/45	4
			Data Handling Tools	30/45	4
		Data Acquisition Systems	Signals & Systems	45	3
			LabVIEW	30	2
			Sensors & Transducers	45	3
		Storage Devices	Storage Media	30	2
			Data Read & Write	30	2
			File Management	30	2
		Field Work	Industry Visit	90	6
			Apprenticeship	90	6
			Project	90	6
2 (b)	Post Diploma Certificate Program (UW Biotechnology Data Logger)	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Data Formats	Data Types	30/45	4
			Data Handling Tools	30/45	4
		Data Acquisition Systems	Signals & Systems	45	3
			LabVIEW	30	2
			Sensors & Transducers	45	3

		Storage Devices	Storage Media	30	2
			Data Read & Write	30	2
			File Management	30	2
		Maintenance/ Repair	Basics of Electronics & Electrical Technology	45/30	4
			Sensors & Transducers	30/45	4
			Circuit Tracing & PCB Basics	30/45	4
			Valves & Actuators	45/30	4
			Planned Preventive Maintenance	45/30	4
		Field Work	Industry Visit	180	12
			Apprenticeship	180	12
			Project	360	24
3	Post Graduate Diploma (UW Biotech Data Analytics)	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Underwater Biotechnology	Bioprocess engineering	45	3
			Bioinformatics/ Marine Genomics and Proteomics/Computational Biology [*Choose 1]	45	3
		Coding	Python/MATLAB	45/30	4
		Introduction to Data Analytics	Statistics	45	3
			Machine Learning	45	3
			Data Visualization	45	3
		Field Work	Industry Visit	90	6
			Project	270	18
4	Post Graduate Diploma in UW Occupational Health & Safety	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Underwater Biotechnology	Marine Pollution and Biological Solutions	45	3
			Ecology &Environment Impact Assessment	45	3
		Underwater Human Resource Management	Safety Management and Communication	45	3
			Risk Management and Control	45	3
			Occupational hazard management / medical surveillance	45/30	4
		Public Health & Policy	Fundamentals of Health and Safety Engineering	45	3
		Field Work	Industry Visit	90	6
			Project	270	18
5	Post Graduate Diploma in UW Environmental & Impact Assessment	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Underwater Biotechnology	Environment Attributes, Setting& Monitoring	45	3
			Marine Pollution and Biological Solutions	45	3
		Introduction to Data Analytics	Prediction and Methods of Impact Assessment	45	3
			Statistics	45	3

			Data Visualization	45/30	4
		Regulations in India	EIA Notification & Marine environment protection acts	45	3
		Field Work	Industry Visit	90	6
			Project	270	18
		Operations	Analytical Methods & Techniques	30/45	4
		Underwater Biotechnology	Bioprocess Engineering	30	2
			Biomaterials & Bioresources	30	2
			Machine Learning	45	3
			Data Visualization	45	3
		Underwater Domain Awareness	UDA Framework	30	2
			Stakeholders & Applications	30	2
		Modelling & Simulation	Basic & Advance Concepts	45	3
		Coding	MATLAB/Python	45/30	4
		Field Work	Industry Visit	90	6
			Project	180	12

Enclosure – 3.3

Course Curriculum – AI and Robotics

The entire curriculum has been designed to meet the job description mentioned above.

Sr. No.	Program Description	Course	Module	Theory/ Practical Hours	No. of Credits
1 (a)	Diploma of Vocation (D.Voc)in Automation and Robotics	Instrumentation	Industrial & Laboratory Instruments	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Maintenance/ Repair	Basics of Electrical and Mechanical systems of Robotics	45/30	4
			Sensors & Transducers	30/45	4
			Planned Preventive Maintenance	45/30	4
			Basics of stacktracing and debugging	30/45	4
			Basics of Soft Robotics	45/30	4
		Field Visit	Industry Visit	90	6
			Apprenticeship	90	6
			Project	90	6
1 (b)	Post Diploma Certificate Program in Automation and Robotics	Instrumentation	Robotic controls and instrumentation	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Maintenance/ Repair	Robot Mechanics	45/30	4
			Sensors & Transducers	30/45	4
			Planned Preventive Maintenance	45/30	4
			Mechanics and control of UW Robotic systems	30/45	4
			Basics of stacktracing and debugging	45/30	4
		Field Visit	Industry Visit	90	6
			Apprenticeship	90	6
			Project	90	6
2 (a)	Diploma of Vocation (Data Management)	Instrumentation	Robotic controls and instrumentation	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Data Formats	Data Types	30/45	4
			Data Handling Tools	30/45	4
		Data Acquisition Systems	DataBase management and governance	45	3
			Data Security	30	2
			Data Warehousing	45	3
		Storage Devices	Storage Media	30	2
			Data Read & Write	30	2
			File Management	30	2
		Field Work	Industry Visit	90	6
			Apprenticeship	90	6
			Project	90	6
2 (b)	Post Diploma Certificate Program (Data Management))	Instrumentation	Robotic controls and instrumentation	45/30	4
		Operations	Analytical Methods & Techniques	30/45	4
		Data Formats	Data Types	30/45	4
			Data Handling Tools	30/45	4

		Data Acquisition Systems	Advanced Database management and governance	45	3
			Data Visualization	30	2
			Advanced Data Warehousing	45	3
		Storage Devices	Storage Media	30	2
			Data Read & Write	30	2
			File Management	30	2
		Maintenance/ Repair	Basics of file handling in SQL and Python	45/30	4
			Data Quality Management	30/45	4
			Data Security	30/45	4
			Data imputation	45/30	4
			Planned Preventive Maintenance	45/30	4
		Field Work	Industry Visit	180	12
			Apprenticeship	180	12
			Project	360	24
3	Post Graduate Diploma (Big Data Analytics)	Instrumentation	Robotic controls and instrumentation	45/30	4
		Operations	Cloud Computing and Operations	30/45	4
		Big Data Technology	Data engineering	45	3
			Data Collection and DBMS	45	3
		Programming	Fundamentals of Python/R	45/30	4
		Introduction to Data Analytics	Statistical analysis with R	45	3
			Applied Machine Learning	45	3
			Data Visualization	45	3
		Field Work	Industry Visit	90	6
			Project	270	18
4	Post Graduate Diploma (Machine Learning Applications)	Instrumentation	Robotic controls and instrumentation	45/30	4
		Operations	Cloud Computing and Operations	30/45	4
		Machine Learning 01	Mathematical foundations	45	3
			Basics of ML workflows and pipelining	45	3
		Machine Learning02	Regression	45	3
			Natural Language Processing	45	3
			Deep Learning	45/30	4
		Digital Image Processing	Text Mining and internet crawling	45	3
		Field Work	Industry Visit	90	6
			Project	270	18
5	Post Graduate Diploma in Advanced Robotics	Instrumentation	Robotic controls and instrumentation	45/30	4
		Operations	UW Autonomous Robot Systems and Robot Operating systems	30/45	4
		Advanced Maintenance and Repair	Mechanics and control of UW Robotic systems	45	3
			Human Centred Robotics	45	3
		Introduction to Data Analytics	Prediction and Methods of Impact Assessment	45	3
			Statistics	45	3
			Data Visualization	45/30	4
		Robot Intelligence	Deep Learning for robots	45	3
		Field Work	Industry Visit	90	6
			Project	270	18

Enclosure-4

Centre of Excellence on Underwater Domain Awareness (UDA) Framework

This proposal includes the establishment of a "***Centre of Excellence***" comprising 5 sub-centres (or verticals), under the MRC, which would be characterised by a strong coherence but with independent activities. All the five centres will draw inputs from each other but have their unique and well defines Key Result Areas (KRAs) and Key Performance Areas (KPAs). The five sub-centres under the Centre of Excellence are listed below:

(a) The first will be ***strategy centre*** that will keep track of the R&D and industry requirements to build effective policy frameworks. There will be data driven policy formulation to address the stakeholder requirements. The KRA for the strategy centre will be to identify gaps in the domestic and regional policies and formulate an effective way forward to build efficient maritime governance. The KPAs will reflect in seamless interactions among the policy makers and the local communities and the key indicator of our success will be policy intervention for enhanced economic growth for the local industry and long term sustainable maritime activities.

(b) The second will be a multi-disciplinary ***research centre*** that will provide cutting edge inputs with site specific field experimental R&D to address the core acoustic capacity and capability building requirements. The IOR with its unique tropical littoral waters needs sustained indigenous R&D efforts to overcome the challenges and capitalize on the opportunities. These efforts should be able to provide nuanced inputs to the strategy centre for effective policy formulation with data driven real time ground understanding. This should minimise the dependence on the technology imports and also enhance our strategic capabilities. Home grown science & technology dominance will minimize strategic risks for security and other critical projects. The activities of this subcentre would be of relevance to our maritime outlook in its widest scope.

(c) The third will be an ***incubation centre*** that will map the research outcomes of the research centre to application specific requirements of the stakeholders. Start-ups and industries can draw ideas from here and build business plans. India's self-reliance on critical strategic issues will be critically dependent on this initiative. The start-ups are always known for their agility to build high-tech solutions and the UDA framework has unimaginable possibilities. The effective eco-system provided by this incubation centre will nurture the talent pool we have in the country and provide innovative directions to channelize their efforts towards nation building.

(d) The fourth will be a ***skilling centre*** that will ensure that the professionals and practitioners from the stakeholders, including partner countries to understand the nuances of the UDA framework and apply them effectively in their

operations and strategic planning. This will not only make our practitioners more scientific and effective in their routine operations but also promote building the national infrastructure and bring seamless collaboration across the stakeholders. This facility will add to our diplomatic leverage in the pursuit of our larger maritime objectives.

(e) The fifth will be the ***academic centre*** that will build academic programs along with project based learning to prepare the next generation of students and professionals to attain higher professional qualifications to appropriately take forward the UDA framework. The professional enhancement will be a very critical aspect to bring regional cooperation. The young generation and the experienced professionals sitting together and working on regional issues need no elaboration for its impact on regional cooperation. These centres will be the hotbed of innovations and ideas for effective progress and seamless interactions at all levels of decision making.

Enclosure-5

UDA Hackathon 2022

Underwater Domain Awareness (UDA) Framework for Effective Realization of the Safe, Secure, Sustainable Growth for All in the Indo-Pacific Region

Background

The young India is a very critical asset that we all talk about today and globally India is being recognized as an emerging nation that cannot be ignored on any front. The young India also poses a big challenge to channelize the abundance of energy in the right direction for nation building. The employability of the graduate students with appropriate skills and understanding of the contemporary issues facing the nation is an important aspect that merits attention. Science and technology will remain a critical driver of national interest and the young India needs to get exposed to finer aspects beyond the theoretical knowledge to make a difference. Focussed and application oriented, project-based approach has always been recognized to make deep impact in the process of learning. Hackathons have been recognized as the right instruments to realize this mission.

The government and the corporates today has taken multiple steps to build maritime infrastructure and integrate the maritime domain with the economic growth engines. India will reach the Rs. 5 trillion economy, only if the maritime sector is able to contribute significantly to the economic growth engines. The Government of Maharashtra has recently announced the setting of a Maharashtra Ocean Applied Science University (MOASU). However, it needs to be recognized that such massive projects require human resource at equally big scale. The high-end technology aspects need, focussed and sustained efforts.

Underwater Domain Awareness (UDA) is a framework that addresses the aspect of ***Safe, Secure and Sustainable Growth*** in the maritime region particularly for the Indian Ocean Region (IOR). UDA is very well aligned to the objectives of the MOASU. It encompasses the ideas of smart digital India with high end technology integration to overcome the specific challenges of the IOR. The effective UDA framework being a new initiative will require efforts in all the dimensions namely - Policy Support, Infrastructure Creation, Know-how Build-up and Human Resource Development. ***Pooling of Resources*** and ***Synergy of Efforts*** are the only way forward is to come together to evolve a nuanced strategic vision. Details on UDA is attached at the end of the document. It will be relevant to stakeholders like:

- **National Security Apparatus** – Indian Navy, Indian Coast Guard, Marine Police, Ministry of Defence, NTRO, Intelligence Agencies and Think Tanks.
- **Blue Economic Entities** – Oil and Gas Sector, Undersea Mining, Ports and Shipyards, Shipping Industry, Fishing Industry, Associated Ministries and more.

- **Environmental Regulators and Disaster Management Authorities** – Government bodies and NGOs.
- **Science and Technology Providers**- DRDO, NIO, NIOT, NCAOR, INCOIS, DST, IMU, Academic Institutes, Associated Ministries and more.

Proposal

The Maritime Research Centre (MRC), Pune in partnership with M/S NirDhwani Technology Pvt Ltd proposes to host the UDA Hackathon 2022. The theme for the Hackathon will be ***UDA for SAGAR 2022***. UDA Hackathon 2022, proposes to organize a three tier, skill/thinking based competition to apprise the participants to the UDA framework and develop their involvement in the SAGAR initiative of the Government of India. It will be a multi-disciplinary project-based competition to expose the participants to multiple issues and aspects based on real world problem solving. It will be driven by the UDA framework in the IOR. It will be relevant to disciplines like:

- All disciplines of Engineering & Technology,
- Marine Science and other Basic Science disciplines,
- Social Engineering and Social Sciences,
- Political Science and Economics,
- Law and Management,
- Geopolitics and International Relations,
- Environmental Sciences and Disaster Management,
- Data Science,
- Underwater Archaeology,

The participants will get exposure to the relevant stakeholders including industries, research organizations, strategic think tanks, users and more as part of the internship programme to be able to understand the requirements and also facilitate their skilling to make them employable. Domain experts will interact with the participants and also guide them in the course of their projects. Experts from academia and research institutes will engage the participants during the knowledge based theoretical components.

There will be two categories for registration - the students and the young professionals. There will be teams of four with diverse disciplines and backgrounds. The teams can be formed among the qualified participants after the first round. The second round will be for forming teams and identifying the project ideas and based on the selected ideas in the second round the third and the final round will be evaluated.

Detailed Programme

The entire UDA Hackathon 2022, has been categorized into three main objectives – Knowledge Enhancement, Upskilling and Encouraging Thinking Abilities through Project Based Learning. Mentoring will be available for the participants for all the three rounds and the mentors will be available to guide the participant’s right from identification of the projects to even planning and execution. The three rounds will be broken down as follows:

Round-1 Basic Aptitude Test

The first round will comprise of selecting the participants with the appropriate skills, knowledge and thinking abilities. The registered candidates will have to submit a poster of their chosen project to be able to demonstrate their aptitude in any of the following:

- algorithm development,
- data analytics,
- robotics,
- thinking skills,
- hardware design & development,
- understanding of any real world problem and more.

Based on their poster presentation and interaction, the selected candidates will move to the round-2.

A panel comprising of experts from the city of origin coordinated by local centre with active participation of MRC Pune, will shortlist the best participants to be selected for the round-2. The panel will comprise of domain experts and academicians from diverse disciplines to identify participants with the appropriate skills and knowledge levels.

Round-2 Exposure to UDA and Team Building

In the second round, the selected participants will be exposed to UDA framework through a two day workshop over the weekend to get started with the second round and also finalize their project ideas and their team members. They get three months to submit their project ideas for the next round.

The evaluation of the project ideas will be undertaken by a panel of maritime domain experts with decades of experience in the maritime domain. These will comprise of senior advisers and experts of the MRC and NDT and also members from the industry. The submission will be online and a detailed format of the project report will be provided. Selected participants of round-2 will be informed electronically.

Round-3 Project Execution and Evaluation

In the third and the final round the participants will be offered a five-day workshop with mentoring to finish their project implementation. The project ideas submitted during the end of second round will be evaluated for their feasibility and execution plan. The winning teams will be invited to MRC Pune to work on their ideas and senior people from the maritime industry will mentor them towards finding workable solutions. At the end of the five-day workshop, the weekend will be used to evaluate the finalist teams.

The final evaluation will be undertaken at MRC, Pune and the teams will be evaluated based on their demonstration of the working model and detailed presentation. The panel will comprise of senior advisers of MRC with diverse expertise and understanding of the maritime domain.

Fees Structure

The fee structure inclusive of GST for the programme will be as follows:

Initial Registration for round-1

(a)	Students with valid IDs	-	Rs. 2,000/-
(b)	Professionals & Faculty Members	-	Rs. 5,000/-

Two-day workshop at the end of round-1, for the selected participants of the competition.

(a)	Students with valid IDs	-	Rs. 2,000/-
(b)	Professionals & Faculty Members	-	Rs. 5,000/-

Five-day workshop at the end of round-2, for the selected participants based on their project ideas.

(a)	Students with valid IDs	-	Rs. 5,000/- (b)
	Professionals & Faculty Members	-	Rs.10,000/-

Prizes and Incentives

There are multiple goodies upto the final team selection at all levels. There will be multiple prizes for the final round.

First Prize for the wining team - Rs. 5 Lakh Cash Prize.

Two second prizes with each winning - Rs. 1 Lakh Cash Prize.
- The team with the most innovative idea
- The team with the best implementation strategy

Four third prizes with each winning - Rs. 50,000/- Cash Prize.
- The team with the most diverse team members
- The team with most promising team members
- The team with the most promising start-up idea
- The team with the most promising blue idea

All the finalists will be offered paid fellowship at MRC, Pune to pursue their research ideas under the guidance of MRC advisers and experts.

Important Dates

Launch of the UDA Hackathon	-	01 May 2022
Registration Closes	-	01 Jun 2022
Submission of Posters for Round-1	-	01 Jul 2022
Declaration of Selected Participants for Round-2	-	01 Aug 2022
Submission of Project Proposal for Round-2	-	01 Nov 2022
Declaration of Selected Teams for Round-3	-	01 Dec 2022
Final Presentation to Jury	-	31 Jan 2023

Enclosure-6

Present Organizational Structure

The organizational structure at the apex level and the ground level are extremely critical to drive any initiative. Typically, we look at the following aspects:

(a) Policy.
(b) Research.
(c) Academia.
(d) Skilling.
(e) Stakeholders.

In this document, we will look at all the five verticals and attempt to find synergy and diversity. The “whole-of-nation” approach will require coherence at a deep level. All the entities have to come together in a synergistic manner whilst retaining their diversity to avoid duplication of efforts.

Policy The policy has two components of government authorities for policy making and think tanks for policy advocacy. There are multiple ministries dealing with water, oceans and maritime activities having diverse mandates and responsibilities. The fragmentation is a concern in terms of resource availability and know how, along with long term S&T focus and sustained effort on skilling & knowledge. The following ministries have significant stakes in the UDA framework:

(i) Ministry of Shipping, Ports & Waterways.
(ii) Ministry of Defence (MoD).
(iii) Ministry of Earth Sciences (MoES).
(iv) Ministry of Jal Shakti.
(v) Ministry of Petroleum & Natural Gas.
(vi) Ministry of Home Affairs (MHA).

There are multiple supporting ministries like the following:

(i) Ministry of Education.
(ii) Ministry of Skilling.
(iii) Ministry of Science & Technology.
(iv) Ministry of Environment, Forest & Climate Change. (v) Ministry of Commerce & Industry.

Then there are some more who could significantly encourage the growth of the UDA framework in a comprehensive manner:

(i) Ministry of External Affairs.
(ii) Ministry of Finance.
(iii) Ministry of Tourism.

(iv) Ministry of Fisheries, Animal Husbandry and Dairy.
(v) Ministry of Agriculture and Farmer's Welfare.

The think tanks have a significant role to look at the policy advocacy. There are multiple generic think tanks that are supporting the government on varied matters. The dedicated think tank on maritime issues is National Maritime Foundation (NMF), initiated by the Indian Navy to exclusively drive the ***maritime security*** issues. ***Blue economy*** is being handled by multiple think tanks like the Research and Information Systems for Developing Nations (RIS), Gateway House, Indian Council for World Affairs (ICWA), Observer Research Foundation (ORF) and more.

At the regional level as well there are multiple entities dealing with the underwater domain issues. These could be named as follows:

(i) Indian Ocean Rim Association (IORA).
(ii) Bay of Bengal Initiative for Multi-Sectoral Technical & Economic Cooperation (BIMSTEC).
(iii) Indian Ocean Naval Symposium (IONS). (iv) Quadrilateral Security Dialogue (QUAD).

The UDA framework could become an agenda point for all these regional forums and India could drive the interaction for policy and technology interventions along with acoustic capacity & capability building initiatives.

Research The research is being undertaken at multiple central research laboratories with reasonable outputs. The Defence Research and Development Organization (DRDO) has three laboratories dedicated to defence research namely:

(i) National Physical and Oceanographic Laboratory (NPOL).
(ii) Naval Science and Technology Laboratory (NSTL). (iii) Naval Material Research Laboratory (NMRL).

The Ministry of Earth Science (MoES) has three dedicated laboratories for ocean technology research for non-military applications, namely:

(i) National Institute of Ocean Technology (NIOT).
(ii) National Centre for Polar and Ocean Research (NCPOR).
(iii) Indian National Centre for Ocean Information Services (INCOIS).

The Ministry of Science & Technology (MoS&T) has its own dedicated laboratory, National Institute of Oceanography (NIO) at Goa, under the Council for Scientific and Industrial Research (CSIR). The NIO, Goa is dedicated for ocean science to meet the requirements of the industry and the common man.

The Ministry of Agriculture and Farmer's Welfare (MoAFW) has its own dedicated laboratory, Central Marine Fisheries Research Institute (CMFRI) for tropical marine fisheries in the IOR. It is part of the Indian Council for Agricultural Research (ICAR) centres across the country.

Academia The academia has a significant role to play and numerous IITs are working on some form of science & technology development to ensure knowledge creation in this niche domain. IIT Delhi's Centre for Applied Research in Electronics (CARE) has been offering masters and PhD program on underwater signal processing and acoustics in a limited form for over five decades. IIT Chennai with its Ocean Engineering Department is giving academic and research support for naval architecture and civil engineering in the underwater domain for over three decades. The Indian Maritime University (IMU), Chennai is a dedicated institute, for the seafarers. It is tightly linked to the International Maritime Organization (IMO) requirements for the seafarers.

Skilling Skilling is the most critical component of the entire initiative to build on the acoustic capacity and capability building. The National Skill Development Corporation (NSDC) has multiple sector skill councils to drive the requirements of the industry and the stakeholders. There is a clear thought process to formalize the entire skilling requirement and delivery. Consolidation has significant value in optimizing the resources and the know-how. The sector skill council for capital goods and strategic manufacturing has multiple stakeholders with high stakes in the UDA framework. There is potential to plan a separate sector skill council for driving the UDA framework given the enormity of the entire application. There are no private skilling centres to drive the requirements of the UDA framework.

Stakeholders The stakeholders in the freshwater, ocean and maritime domain include numerous entities with unique requirements and mandates. The stakeholders can be categorized into three distinct groups:

(i) **Maritime Security:** The maritime security has two distinct components dealing with internal and external security under the ministry of defence and the ministry of home affairs. The water bodies, both in the maritime and the freshwater systems have significant vulnerabilities given the political volatility and non-state actors in the IOR. The list of entities could be as follows:

(a) Indian Navy under the MoD.
(b) Indian Coast Guard under the MoD.
(c) Paramilitary forces deployed in the border areas for protection of the water bodies. These are under the MHA.
(d) Marine Police under the respective State Governments in the nine coastal states.

(ii) **Blue Economy:** The blue economy has multiple entities and diverse activities involved. The entities could be categorized as follows:

(a) Shipping industry both in the private and public sector.
(b) Minor and major ports in the entire coastline.
(c) Inland waterways.
(d) Deep sea mining.
(e) Fisheries.
(f) Defence industry.

(g) Oil & gas industry.
(h) Ocean Energy.

(iii) **Environment & Disaster Management:** The environmental regulators and the disaster management authorities have a very critical requirement of situational awareness and predictive assessment. The following are the established entities:

(a) National Coastal Zone Management Authority (CZMA).
(b) Central Ground Water Board (CGWB).
(c) Environment and Pollution (Prevention and Control) Authority.
(d) Central Pollution Control Board (CPCB).
(e) Central Water Commission (CWC).
(f) National Disaster Management Authority (NDMA).
(g) National Green Tribunal (NGT).

The three stakeholders need to be equipped with the adequate skilling, knowledge and infrastructure to be able to drive the national dream effectively. They are the users and also the wealth creators to drive the UDA framework comprehensively.

It is clear from the above description, that multiple agencies are engaged in diverse activities to complement the UDA framework, however there is substantial lack of synergy. The mandates of the organizations, authorities, stakeholders and others, limit their ability to build scale of a reasonable size to bring efficiency and effectiveness. The fragmentation prohibits synergy and at times encourages duplication & turf wars.

Enclosure-7

Specific Recommendations

Policy Intervention will have to be multidimensional and multifunctional to manage the complexity of the entire effort. The "***whole-of-nation"*** approach has significant challenges at the policy level. The apex policy authority that can drive this initiative has to be identified and approached. There are multiple ministries looking at varied dimension of the MDA and each of them have their own financial and political authority. We need a centralized authority that can have appropriate political and financial powers to drive this initiative comprehensively. A complete organizational framework that can build the entire initiative with nuanced policy intervention, technology intervention along with capacity & capability building is required. Issues at the union government levels, state level and also the issues concerning the federal structure need to be identified and addressed. An empowered ***Group of Ministers (GoM)*** to work on the broad organizational structure has to be formulated. The GoM will review the draft organizational structure at the union government level. A ***parliamentary standing committee*** may also be formed to discuss the larger socio-economic, sociocultural and socio-political dimensions.

A ***regulatory authority*** that can monitor and account for all the underwater activities across the maritime domain and the freshwater systems will have to be set-up. This body will cut across multiple ministries and build a synergised framework to enhance efficiency and effectiveness. The precise mandate and authority of the body will have to be articulated with significant deliberations. The larger objective should be to build a safe, secure, sustainable growth model.

A ***strategic vision document*** will have to be prepared, to articulate the detailed mandate of the GoM, parliamentary standing committee and the regulatory authority. As a follow-up to the interim report, MRC may be tasked to work on the strategic vision document with co-opted members from government authorities and agencies. The core team working on the strategic vision document will be the back office of the GoM and the parliamentary standing committee. This team along with the GoM and the parliamentary standing committee will work for one year to build the comprehensive strategic vision document for consideration of the Government.

A structured drive will be required from six months prior to the starting of the strategic vision document work to sensitize and bring everybody onboard. The ***UserAcademia-Industry*** partnership will be better managed with this drive. The drive will be three tiered, as follows:

(a) **Outreach** Workshops, seminars, corporate interactions and more will be planned and executed across the stakeholders, policy makers, practitioners, think tanks, communities and more to get their inputs on this initiative right at the beginning. The concerns and aspirations will be weaved into the strategic vision document.

(b) **Engage** The outreach will have to be converted to engage with the pool of young students and professionals to work on specific ideas for furthering the UDA framework. We will have to institute UDA fellowships to support the young students and professionals for sustaining them for a longer duration and encouraging them to choose this domain as a career option. These UDA fellows will be the core team to undertake research and detailed study for the strategic vision document.

(c) **Sustain** The engagement with the stakeholders and policy makers will have to translate to a deeper project based sustained collaboration to allow long term support for this initiative. The project funding and the support from the stakeholders and policy makers will be the key, to sustaining this initiative and developing a more meaningful partnership. The deliverables of the projects will be a critical input to the strategic vision document.

The submission of the strategic vision document will give far more clarity to the shape of policy framework and larger national, regional and global organizational structure both at the government and the private sector. The setting up of the ***Centre of Excellence*** (COE), now becomes an important backend knowledge centre to build this massive initiative seamlessly. The core team of the COE will come from the pool of skilled and knowledgeable UDA fellows nurtured during the ***engage*** and ***sustain*** efforts earlier. The COEs have to be focused on and backed by appropriate authorities and stakeholders. The following COEs are proposed:

(a) Centre for Coastal Governance The nine coastal states along with the Ministry of Shipping, Ports and Waterways can set-up a Centre for Coastal Governance. This will deal with issues of the coastal state and provide policy & technology intervention along with acoustic capacity & capability building.

(b) Centre of Excellence for Sustainable Blue Economy The Ministry of Earth Sciences (MoES) could back the Centre of Excellence for Sustainable Blue Economy. The massive blue economy push across stakeholders and policy makers will be supported by this centre.

(c) Centre of Excellence for Inland Water Transport The Inland Water Transport Authority under the Ministry of Shipping, Ports and Waterways could drive this centre. The Inland Water Transport is a mega project and needs substantial hand holding.

(d) Centre of Excellence for Freshwater Management The Jal Shakti Ministry could drive this centre with massive requirements across multiple applications of freshwater resource management and quality management.

(e) Centre of Excellence for Strategic Security The Ministry of Defence and the National Security Adviser could drive this centre for looking at varied strategic security issues. This becomes and backend knowledge centre to support their decision making in a seamless manner.

(f) Centre of Excellence for Water Dependent Communities The coastal communities and the inland communities dependent on freshwater systems need to

be supported with enhanced inputs on their synergy with the water bodies for a sustainable future. The Ministry of Agriculture & Farmers Welfare and the Ministry for Fisheries, Animal Husbandry & Diary could come together to drive this centre. Master plans for sustainable growth is a critical aspect that requires urgent action.

(g) Centre of Excellence for Underwater Archaeology The traditional knowledge is a very critical input required to drive the modern developmental projects. India has a rich maritime heritage being one of the oldest civilization and cannot afford to lose the knowledge we have accumulated over centuries. Enough is there across the country and beyond that will be very important for us to drive the maritime aspiration in a nuanced manner. This centre can be supported by the Ministry of Culture and Ministry of Science & Technology.

These centres will initially start operating in a small manner to build on the basic knowledge and know-how, along with the pool of multi-disciplinary human resource. At a later date, they all could be combined to build an ***Inter University Centre*** (IUC) on the Underwater Domain Awareness (UDA) Framework to comprehensive drive this initiative in a structured manner. The strategic vision document will look into this aspect of ***COE Versus IUC***. The ***consolidation versus diversity*** is an important debate that will have long term ramifications.

The innovation is a hall mark of any new initiative. The crowd sourcing of ideas is a time-tested method to build big initiatives and also allow ownership to the larger community. India with a massive demographic dividend must channelize the energy and aspiration of the young India into nation building. ***UDA Hackathon*** is an effective means to generate the excitement among the young India and channelize their young minds into such a unique and niche domain. The diversity and the traditional knowledge across the country can be effectively harnessed through this method. An intense engagement with young India can be achieved with the UDA Hackathon. In the lines of Start-up India initiative, UDA Hackathon can be started and executed on an annual basis. MRC will take full responsibility for the same. The Ministry of Education and Ministry of Skilling could drive this initiative.

The ***UDA for SAGAR*** initiative will be an important project to showcase India as a knowledge & skilling hub in the IOR and beyond. The Ministry of External Affairs (MEA) is anchoring the SAGAR vision of the Honourable Prime Minister so the UDA for SAGAR initiative could be driven by MEA. This will include workshops, seminars, training programs, UDA fellowships and projects relevant to the Indo-Pacific Region for policy & technology intervention along with acoustic capacity 7 capability building for their students and young professionals.

Enclosure-8

Maritime Research Centre (MRC) and its Contribution

The MRC, Pune is a not-for profit organization, dedicated to progress the Underwater Domain Awareness (UDA) Framework across all the horizontal and vertical dimensions. The MRC is a technology driven think tank to provide policy & technology interventions along with acoustic capacity & capability building to all the stakeholders and the government authorities. The MRC, in the last five years have developed certain unique & niche domain expertise and strategic capabilities to provide a comprehensive way forward for driving the UDA framework at the national, regional and global level. MRC is supported by M/S NirDhwani Technology Pvt Ltd, a start-up with the ability to drive turnkey projects involving field experimental efforts. NDT is backed by former navy personnel with significant sea experience to undertake deployments on water bodies. MRC and NDT together are progressing the UDA framework in a nuanced manner. The details are attached below:

Policy Intervention

(a) The ***Honourable Raksha Rajya Mantri, Shri Subhash Bhamre*** chaired a one day seminar on the UDA framework for SAGAR and acknowledged that the UDA framework should be given national priority. The resolution passed at the end of the seminar and endorsed by multiple senior experts and strategists also called for establishing a Inter University Centre (IUC) for the UDA framework.

(b) The ***National Security Adviser*** (NSA) office has taken cognizance of the UDA framework and its relevance to strategic security requirements in the country. The National Security Council Secretariat (NSCS) is engaging with MRC to build multiple policy structures based on the UDA framework.

(c) The ***Indian Navy*** (IN), recognizes the relevance of the UDA framework and its strategic & tactical applications for their maritime security role. The IN has been engaging with the MRC to design and develop multiple modules to support their futuristic requirements.

(d) The ***Chief of Defence Staff*** (CDS), the ***Indian Army Chief*** and the ***Defence Secretary*** have taken cognizance of the policy paper submitted by MRC on the UDA framework under the mentorship of Lt Gen D B Shekatkar (Retd) PVSM, AVSM, VSM. The interactions are ongoing.

(e) The regulatory framework and monitoring mechanism proposed by MRC for marine conservation, specific to noise pollution due to increasing shipping traffic in the IOR has been sent as India's proposal to the International Maritime Organization (IMO) by the ***Director General Shipping***. The IMO's Marine Environment Protection Committee (MRPC-76) has taken cognizance of the paper in their June 2021 meeting and included India in the committee set-up to drive the same for global policy

framework. The proposed framework from MRC, addresses the unique challenges & opportunities of the tropical littoral waters.

(e) The ***All India Council for Technical Education*** (AICTE) has approved the Acoustic Survey modules across multiple levels. These modules are the main stay for the massive maritime and inland water transport push by the Government of India. The policy approval was facilitated with the direct intervention from the Chairman AICTE, given its relevance to the SAGAR vision of the Honourable Prime Minister.

(f) The skilling modules on the Acoustic Survey have also been approved under the ***Pradhan Mantri Kaushal Vikas Yojna*** (PMKVY). The ***National Skill Development Corporation*** (NSDC) has signed a MoU with MRC, to further the skilling requirements for the mega projects by the Government of India. The Ministry of Shipping, Ports and Waterways has asked MRC to partner them on the skilling requirements of the Ministry. The interaction is ongoing and the ***Honourable Minister, Shri Sarbananda Sonowal***, met MRC team and discussed the details.

Technology Intervention

(a) The marine environment monitoring and analysis tool developed by MRC & NDT has been recognized at the Narwhal Challenge. The Narwhal Challenge is a global maritime innovation challenges hosted by the French city of Brest. The MRC & NDT entry was among the four shortlisted globally in 2019. This innovation can support and drive multiple tech start-ups in India and the Indo-Pacific Region, given the tropical littoral waters. The multiple dimensions in the innovations have several offshoots.

(b) The Artificial Intelligence (AI) based Submarine Deployment Tool, developed by NDT has been adjudged as the top eight defence innovations by the European based Defence Technology Group. The group has been hosting the annual Underwater Defence Technology (UDT) conference for many decades.

(c) NDT is the R&D partner to M/S Bharat Electronics Ltd (BEL) Bangalore for supporting their UDA technology development. BEL, Bangalore is a NavRatna PSU of the Government of India to support the requirement of the Indian Defence organizations. Multiple project are being processed for joint development.

(d) The Indian Navy is also processing multiple technology projects for maritime intelligence and sub-surface surveillance. The technical and operational feasibility has already been established by high level review and the financial processing ongoing.

(e) MRC and NDT has been engaged in developing over 50 innovative project ideas to support the start-up ecosystem. These projects represent the multiple cubes of the UDA framework. The core technologies include signal processing, data analytics, AI & ML, underwater robotics, sensor technology and more.

(f) MRC and NDT have undertaken detailed modelling & simulations of the Khadakwasla Lake at Pune for its sediment classification problem. The models were validated using field experimental real data collection using four different sonars

including side scan sonar, sub-bottom profiler, single beam sonar and CTD probe. Massive data collection across acoustic sensor data, environmental data from online sources and others was undertaken to analyse the sediment situation in the lake. It was part of a PhD research by a MRC research scholar. The PhD thesis has been accepted with high appreciation of the real-world problem-solving contribution.

Acoustic Capacity & Capability Building

(a) The MRC & NDT has been hosting UDA Summer School since 2017. It is a six weeks residential program for participants from across the country and diverse stakeholders. The program is supported by multiple stakeholders, including DRDO, CSIR, Indian Navy, Indian Coast Guard, Industry, DST, Think Tanks, IITs and more. The event is hosted four weeks in Mumbai/Pune University and two weeks at NIO Goa. The resource persons include domain experts from the government, academia, Industry and more, and the strategic and policy experts come from the Government authorities and think tanks. The peer learning format has worked very well and the participants get a very diverse exposure along with delivering a specific project on certain real-world issue, that they can take forward as their career option. The connect with the industry is also very effective to understand the new opportunities.

(b) Students from premier academic institutes like IITs, BITS Pilani, IIMs and others join for a separate eight weeks internship program with focus on innovative technology development. Over 100 such students have worked with MRC to build on a significant body of work that can be translated to the start-up ecosystem. These are multidisciplinary students with high calibre and intense motivation to deliver.

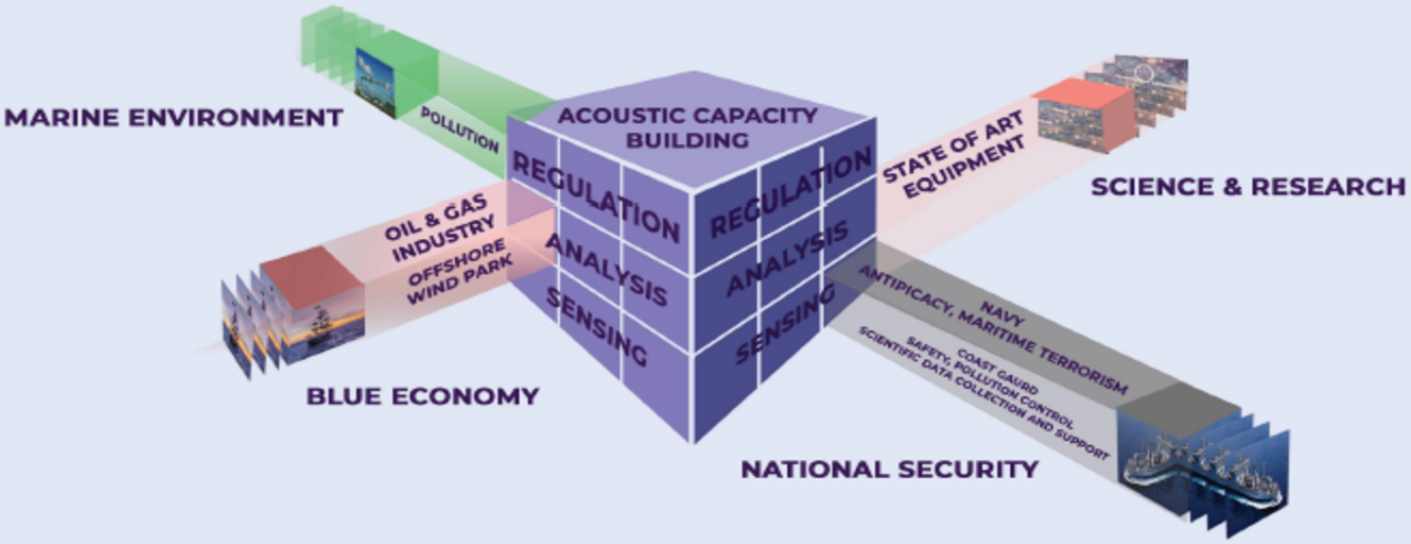
(c) MRC and NDT have been undertaking corporate training for large PSUs and Industries engaged with the Defence and maritime sector. These corporate training modules are for multiple levels of participants and diverse technology and strategic topics.

(d) Workshops and seminars are being organized on a regular basis for students & faculties in academia and also industries. The students and young professionals can relate to this new domain and understand the possible career opportunities for them in future.

(e) UDA webinars have sensitized senior functionaries across the stakeholders, policy makers, industry, think tanks and more. These webinars have generated significant awareness about the UDA framework and now we are engaging with these entities to collaborate and partner them in the larger UDA initiative.

(f) The Centre of Excellence (COE) as proposed by MRC, is a very unique and comprehensive structure to drive the UDA framework. Multiple academic and industry entities are interacting with MRC to collaborate for setting up such COEs.

Underwater Domain Awareness (UDA) Framework



Government

Academic Institutions

Think Tank & Policy Makers

Shipbuilders & Port Management Authorities

UDA For Blue Governance

U/W Robotics

U/W Signal Processing

Modelling & Simulation

Data Science

Digital India

Startup India

Skill India

Make in India

Sediment Management

Inland water Transport

Port Management

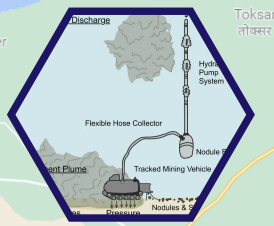
Shipping Industry

Oil & Gas Industry

Snapping Shrimp Farming

Waste Management

Undersea Mining



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