**Underwater Search & Recovery (UWSAR): Challenges and Opportunities in the Indian Ocean Region (IOR)**

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***Abstract*** The Indian Ocean Region (IOR) is strategically gaining substantial relevance, resulting in massive maritime build-up both militarily and otherwise. The increasing maritime build-up, exposes us to vulnerabilities related to accidents and losses at sea of both human and high value assets. Underwater Search & Recovery (UWSAR), is becoming critical, thus effective & efficient capability and capacity building is inescapable. It is important to appreciate that UWSAR is far more complex compared to the conventional SAR on the surface and therefore a very different set of acoustic capability & capacity building is necessary. The IOR with its tropical littoral waters further presents very unique challenges in terms of sub-optimal performance of the sonars deployed for acoustic surveys. The random fluctuations in the acoustic propagation characteristics in the underwater medium is the major contributor to the sub-optimal performance. Import of underwater hardware from the west has not helped in the absence of indigenous efforts towards customizing the algorithms to the local ground realities. Massive field experiments involving Shallow Waters Acoustic Measurements (SWAMs), preceded with Modelling & Simulation (M&S) efforts to map the underwater characteristics are necessary to enhance the sonar performance. The developing nation status with pre-modern governance structure limits the possibility of allocation of such massive resources to R&D for futuristic strategic vision. The political leadership get caught up in day today socio-economic crisis, limiting their strategic vision. The extra-regional powers find it easy to exploit the fragmented governance structures where the stakeholders are not able to come together and work in a coherent manner. The extra-regional powers continue to supply hardware at a very high cost with minimal applicability to the local site specific deployments. The work attempts to highlight the challenges and opportunities of UWSAR in the tropical littoral waters of the IOR. The entire process of UWSAR is presented with detailed analysis of each module from a multi-disciplinary approach including geo-politics, science & technology requirement, human resource development and more importantly the strategic vision gap. A unique Underwater Domain Awareness (UDA) framework is proposed to overcome the challenges and facilitate pooling of resources and synergising of efforts across the stakeholders to optimise the resource deployment. The stakeholders ranging from security, blue economy, environment & disaster management and science & technology need to come together under the UDA framework to derive maximum coherence for nation building. The same model can also be extended beyond the national boundary to the IOR and India as a nation could play a leadership role with science & technology being the main driver for regional integration to be able to keep the extra-regional powers at bay. The UDA framework can truly promote safe, secure, sustainable growth for all in the region. The UDA framework as proposed by MRC could be replicated in other parts of the globe to achieve greater peace and prosperity.

**Keywords** Indian Ocean Region (IOR), Tropical Littoral Waters, Underwater Search & Recovery (UWSAR), Underwater Domain Awareness (UDA) Framework, Acoustic Capacity and Capability Building.

**Introduction**

The Indo-Pacific strategic construct is largely spread across the tropical littoral waters of the IOR and the South China Sea (SCS). The global power play and strategic exchanges are taking place in these maritime spaces. Thus, maritime activities and the military presence in the maritime space have scaled up to unprecedented levels. The Security And Growth for All in the Region (SAGAR) declaration by the Indian Prime Minister in May 2015, is another big announcement to boost maritime capability and capacity building, not just for India but for the entire IOR [1, 2].

The entire focus of naval deployments is increasingly shifting towards Submarine operations and also submersibles. According to the former Indian Naval Chief “Currently, the PLAN’s submarine fleet of more than 60, includes diesel boats of the ‘Yuan’, ‘Kilo’, ‘Song’, and the obsolete ‘Ming’ classes, while the nuclear force includes five SSNs; three of the ‘Han’ class plus two ‘Shang’-class boats, and five SSBNs; one of the ‘Xia’ class and four of the ‘Jin’ class”. The other Navy’s in the region with minimal resources and capabilities are also jumping on to the band wagon of acquiring and deploying submarines. Vietnam, Bangladesh, Thailand and Myanmar are the new entrants to the club along with players like Indonesia, Malaysia, Pakistan and Singapore [3]. Barring a few like Singapore, it is important to note that these nations lack maturity and experience to manage a submarine fleet with all its complex dimensions. With such aggressive proliferation of not just conventional submarines, but also nuclear submarines in the region the risk of accidents and sabotage leading to catastrophic consequences needs no elaboration. UWSAR capabilities are receiving minimal attention, however the relevance needs no emphasis [1].

The ***Strategic Stability*** at sea achieved during the Cold War period was based on three premises [4]:

(a) The submarines possessed a secure stand-off capability due to the long range of their weaponry;

(b) The submarines, due to their nuclear power and the limits of then available anti-submarine warfare (ASW) technology, had the ability to hide anywhere in the world’s oceans, thus rendering them virtually invulnerable to detection and attack;

(c) No exports of this technology would ever be allowed because of the risks posed by the presence of multiple actors able both to deliver nuclear weapons at sea and possess full nuclear-fuel-cycle capabilities.

In the 21st century, none of these assumptions hold good and thus the strategic stability is increasingly under threat. The emergence of new technologies and new actors in the underwater domain, particularly in the politically unstable regions of IOR and SCS, makes it a deadly cocktail of sub-optimal capability to handle such complex systems and the lack of maturity to manage conflict and confrontation. The increasing proliferation of submarines, both conventional and strategic with arsenal of WMD (Weapons of Mass Destruction) levels and autonomous underwater vessel technologies of all calibres poses new risks. Such developments can lead to dangerous encounters between hostile submarines and heighten the chances of accidents, including collisions involving nuclear submarines with catastrophic consequences [4].

The MH370 accident generated significant debate on UWSAR, particularly on the collective SAR capabilities that exist in the IOR. The Indian Ocean Rim Association (IORA), has emphasized on a regional model for SAR capability and capacity building for maritime and aviation related incidents. The Perth Communiqué in October 2014, encouraged dialogue between the IORA and the Indian Ocean Naval Symposium (IONS). Numerous commentators recognize that the IORA being a politico-diplomatic forum for member states to formulate regional arrangements and policies, the IONS could complement as a platform for executing the agreed national commitments. Notable among them would be ‘concept-development and associated table-top and/or real-world exercises’ on SAR including submarine rescue. Many such forums and platforms have remained limited to dialogues, conferences and workshops and have failed to go beyond to evolve an organizational structure with appropriate infrastructure for quick and effective response in case of an incident [5].

In his address to the IONS on 11 Jan 2016, Vice Admiral Tim Barrett, AO, CSC  
Chief of Navy, Royal Australian Navy, brought out the importance of Cooperative Maritime Search and Rescue in the Indian Ocean Region. He talked about the MH370 incident as a case study and stressed on enormity of the task. Australia was chosen by the world community to lead and coordinate the effort. He recognizes that the sheer scale of the entire operations including deployment of air assets, surface maritime assets and underwater assets, could overwhelm any single nation even in the developed world with significant resources. The planning and management of the entire operations were of unprecedented level requiring involvement of multiple stakeholders including the scientific & research community, deployment experts, logistics, communication and much more [6].

In the IOR, more recently on 22 Jul 2016, we had the tragic case of an AN-32 aircraft of the Indian Airforce disappearing, while flying over the Bay of Bengal. There were 29 people on-board. The Radar contact with the aircraft was lost at 0912 hrs, 280 kms east of Chennai. The SAR operation for the AN-32, became India’s biggest for a missing plane at Sea in history. The Indian Navy and the Indian Coast Guard launched a large SAR operation with a submarine, twelve surface ships and five aircrafts. Three days after the disappearance, sixteen ships, a submarine and six aircrafts were deployed to further augment the SAR mission. On 15 Sep 2016, the SAR operation was called-off, and all the 29 people on-board were presumed dead and their families were notified [7]. There were multiple limitations highlighted in the aftermath of the tragedy to account for the inability to find the aircraft including the absence of certain fitted equipment on-board the AN-32 like the Underwater Locator Beacon, Automatic Dependent Surveillance – Broadcast and others [8]. The incident, not only highlights the tragic loss of life, but the inability to find the bodies of the people on-board further deepens the pain for the families. Most critical is the disappearance of the wreckage, including the flight recorder that would have given us, clues on the cause of the accident and facilitate proper closure to the incident.

The UWSAR operations has its own challenges pertaining to resource availability (air assets, surface assets, underwater assets, etc.,), knowhow (science & technology, deployment, etc.,), human resource and more. The challenges are economic, political, physical and more. We discuss the challenges and opportunities in the next sections and attempt to present a way ahead for effective UWSAR in the IOR. The Underwater Domain Awareness (UDA) framework remains the driver for all such issues.

**Indian Ocean Region**

The IOR is emerging as the most strategically important region and also getting exposed to the consequent vulnerabilities as well. Political and economic factors are abetting the strategic risks in terms of stability and security, thereby resulting in hectic maritime activities [9]. To add to that the tropical littoral conditions further ensure sub-optimal performance of the sonar deployed for any acoustic survey task [10].

The **economic** aspect is highlighted by the fact that the IOR is the most critical area globally, in terms of international energy and commerce that crosses these waters. Forty percent of the global energy flow now happens across the IOR, largely from the west (Persian Gulf) to east (China, India, Japan). Whereas, in the reverse direction we can see Super-ships carry manufactured goods from Asia to the Middle East and Europe [11]. The economic potential also spans from deep sea minerals to fisheries to the tourism that depends on tropical islands and coral reefs. In terms of deep sea minerals, the IOR is richest in minerals (after the Pacific Ocean) including oil and gas, polymetallic sulphides, cobalt-rich crusts and other materials that have high potential for economic development and exploitation [12].

The lack of governance and the poor economic condition is a dangerous combination for the **geopolitics** of the region. The movement of high value cargo coupled with the political instability and vulnerable socioeconomic condition in the region has given birth to piracy and terrorism (more often than not interlinked and connected). Thus, this puts the security apparatus from the region and otherwise to be on alert and continuously deployed in the region. At times even nations with small economics get involved in political sparring due to unregulated undersea resources [13]. The asymmetry of economies and political power compounds the challenge. The developed nations use the high seas for strategic objectives, like for example, China has significant interest in the region for ensuring energy security. The IOR now being a major Sea Lanes of Communication (SLOC), has generated significant security related concerns for the major economies worldwide. Given the piracy related incidents along the Somalian coast and the larger IOR, is encouraging many great power navies to maintain their presence in the region as part of the counter piracy coalition. The volatility of the regional powers has been never ending [14].

The lack of maritime policy in the earlier days of poor accessibility for the Rim countries in the IOR is a thing of the past. In today’s interdependent and highly mobile world, the maritime resources need to be better regulated under a policy framework to avoid conflict and bickering among weaker nations. Terrorism with its global access and unprecedented resource mobilization ability has taken dangerous proportions in the highly unregulated maritime domain. The global maritime commons (sea routes) have become facilitators of disruptive activities by the subversive groups, sometimes supported by disgruntled nation states as well [14].

The last but not the least aspect is the **physical** one. The data recorded at the receiver by an underwater sensor gets significantly modified due to the medium fluctuations as it propagates from the source to the receiver. The recorded data acquires characteristics far different from the signal of interest (as emanating from the source) due to propagation from the medium that could corrupt the analysis findings. The littoral waters due to the close proximity of the two boundaries (sea surface and sea bottom) cause multiple interactions with the boundaries while propagating from the source to the receiver and thus get modified by the surface and the bottom behaviour. To add to that, the tropical waters further, display random fluctuations of the sea surface, varied bottom characteristics and also a rich bio-diversity of the volume causing higher distortions to the signal of interest. The tropical littoral waters of the IOR present unique acoustic behaviour that complicate the understanding of the undersea domain. The sensors designed and developed for the temperate and the Polar Regions (where the design and development has largely taken place due to the requirement of the cold war period) do not work optimally and require site specific customization [15]. The customization of the underwater environment requires huge amount of field work with significant funding support [10].

The IOR is facing a very unique challenge in terms of the maritime governance. The developing status makes it politically unfashionable to promote long term Research and Development (R&D) at the cost of economic progress. The rapid pace of development has made sure systems and maritime infrastructure have been developed in a regulatory vacuum. The scientific inputs and the technology to support scientific investigation has been a weak area, so maritime governance has remained adhoc, to say the least. The political volatility and the socio-economic status are creating more panic and maintaining an overactive security apparatus in the maritime domain. The inaccessible and invisible undersea domain makes it politically irrelevant to allocate resources for generating enhanced understanding and even initiate regulatory framework. The strategic emergence of the IOR today makes it even more imperative that we wake up sooner than later to first recognize and then address this issue of Acoustic Capacity and Capability Building. The first step would be awareness make the stakeholders to recognize the problem and initiate measures.

The UWSAR, has multiple dimensions to it with complex interdependencies. A nuanced way forward is critical with urgent measures to overcome the challenges of the IOR as discussed in this section. There are no short term solutions to the problem at hand. A comprehensive framework with optimization of resources and efforts is the only way forward. Given the challenges, it also presents a substantial opportunity to project ourselves as a leader in the region with technological superiority and effective infrastructure and framework to provide UWSAR as a diplomatic tool to encourage regional cooperation and consolidation.

**Underwater Search and Recovery (UWSAR)**

The UWSAR essentially pertains to search, recovery and salvage of high value objects that have been lost on the sea bottom. Rescue by and large pertains to human survivors, however it may be important to acknowledge that human survivors may not last long underwater. Given the extended lead time required to mobilize the SAR assets for a meaningful operation, the chances of finding a survivor us remote. Thus, the conventional requirement of search, recovery and salvage relates to aircraft black boxes, underwater vehicles and other types of objects. The UWSAR, traditionally translates to handling emergencies in the offshore and shallow water areas with water depths of the order of several hundred meters. Documented literature reveals that more than 84% of the ocean have depths in excess of 2,000 km. Thus, with increasing human activities in the maritime domain, such emergencies are only going to increase and will require special efforts. Though very expensive, the underwater search and recovery has continued, as the inputs have critical scientific significance and engineering practical value for improving their safety and reliability [16].

The MH370 search had multiple lessons to be learnt, as we plan ahead for any such eventuality in the future for UWSAR. The aircraft lost contact with the Air Traffic Control (ATC) on 08 Mar 2014, during a transition of air space between Malaysia and Vietnam. The aircraft is yet to be recovered and the cause of disappearance remains unknown till date. The search began on the Gulf of Thailand and the South China Sea, where the aircraft signal was last detected on the secondary radar. Analysis of the satellite communication between the aircraft and the Inmarsat’s communications network gave clue that the aircraft continued south into the Southern Indian Ocean. On 17 Mar 2014, Australia was given charge, by the global community to lead the UWSAR. A comprehensive survey of 120,000 sqkm of sea floor in an area about 1,800 km south-west of Perth, Western Australia was then carried out. The search yielded no evidence of the aircraft [17].

The entire process of UWSAR has multiple dimensions and the sequence of steps to be taken needs to be understood before we attempt any further elaboration on Challenges & Opportunities. As soon as the incident of any maritime accident is reported that may require UWSAR, the first prima facie establishment of no human rescue requirement, needs to be made. Otherwise the urgency and detailing becomes very different. The steps are as follows:

**Step-1 Marking of the last known position of the platform.** This is a very critical step as the entire start of the UWSAR begins from here. The oceanographic parameters at the marked position and the continuous recording of these parameters from the time of the incident become a very critical input.

**Step-2 Modelling and Simulation (M&S)** The movement of the platform from the last known position till the actual search operation is initiated and beyond becomes important to plan the entire search operation. The platform has to be monitored till it settles down in a stable position in its final resting location. This monitoring is undertaken using M&S that gets inputs on the oceanographic parameters to estimate the movement of the platform from the last known position. The model provides the framework and based on the platform and oceanographic parameters fed to the model, extensive simulation is undertaken to generate possible movement of the platform.

**Step-3 Ground Information** The inputs on the underwater features is extremely critical to plan the survey (search operation). Availability of inputs on the bathymetry, sediment type and macro underwater features in the search area could be a leg-up, otherwise such survey may have to be undertaken as a pre-requisite. Acoustic surveys have their own challenges, particularly in the tropical littoral waters.

**Step-4 Finalization of the Search Infrastructure** The inputs from step-1, 2 & 3, will determine the search infrastructure/tools. The sensors (type of sonars in terms of frequency as well as spatial coverage), platform for mounting the sensors (surface using ships or underwater using manned/unmanned platforms), data processing requirements (based on search area and the volume of data recorded) and more.

**Step-5 Mobilization of the Search Operation** The actual mobilization of the search operation will be governed by the earlier steps. The tropical littoral condition, proximity to the search area, availability of the search resources and more will determine the entire search pattern and the corresponding logistics. The M&S will support optimization of the entire effort based on precise inputs of the local site specific conditions as discussed in the earlier steps.

**Step-6 Salvage/Recovery Operation** Once the platform is located, the salvage/recovery is again a completely different operation and highly specialized. Based on the platform to be salvaged/recovered, the requirement of infrastructure and the tools will be finalized. Underwater Salvage is a highly specialized exercise and requires unique equipment’s that are available with very few countries or organizations globally. Thus, right at the beginning, these factors need to be ascertained.

Basics of UWSAR

Rescue Vs Recovery

Type of Asset Deployment

Initial Reporting

M&S

Mobilizing the SAR assets

Data Collection & Analysis

Actual Rescue/Recovery

**Acoustic Capacity Building**

Also talk about UDA

**Regulatory Framework**

**Conclusion**

Short Term, Mid Term and Long Term

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