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Building Maritime Partnerships with Ocean Science and Technology

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Oceans link India across the continents in its benign quest for peace and tranquility. Compared to the vastness of the oceanic imponderables, the understanding of the oceanic environment appears to be in its infancy. There is a need to enhance information about the oceanic sciences across large distances and great depths, as this would enhance national security. This is well beyond the resource capacity of any one nation in the Indian Ocean Region. As a first step, the area of cooperation can include the setting up of sea observatories. This would require collaboration in sensor technologies for ocean environment, computation and processing ability, management of information, and enhanced communication systems over and under the seas. Such partnerships would create enhanced oceanic information zones, which would help strengthen the national security of a nation as well as regional maritime security.

Introduction

The Indian Ocean is the third largest of the world's five oceans after the Pacific Ocean and Atlantic Ocean. On the north it is bound by the southern limits of the Arabian Sea,

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Lakshadweep Sea, the Bay of Bengal and the southern limits of the East Indian Archipelago and the Great Australian Bight. On the west it stretches from from Cape Agulhas to the Antarctic Continent along the 20° longitude East Meridian, whereas on the east its boundaries are drawn from the South East Cape and the southern point of Tasmania down to the Antarctic Continent. On the south it borders the Antarctic Continent. It touches the shores of 38 countries and has prolific oil and trade transit routes. Its resources include abundant amounts of fish, hydrocarbons and minerals. Polymetallic nodules which contain nickel, cobalt, iron and manganese, and polymetallic massive sulphides (PMS) containing copper, iron, zinc, silver and gold are also found in the Indian Ocean at depths of 4000 to 5000 m. South Africa and Mozambique abound in coastal sediments which contain titanium and zirconium, and tin placer deposits are available off the coasts of Indonesia, Thailand and Myanmar.

Major Initiatives in Ocean Science and Technology by the Government of India

Seabed Surveys

By March 2011, Indian agencies had carried out reconnaissance mapping of about 85% of the offshore area within the territorial waters (TW) and almost the entire seabed within the Exclusive Economic Zone (EEZ). The collection of offshore data was carried out by many agencies such as the Geological Survey of India (GSI), the Indian Navy, Oil and Natural Gas Corporation Limited (ONGC), National Institute of Oceanography (NIO) and departments of the Ministry of Earth Sciences for scientific, economic and strategic purposes. The main task of GSI is seabed mapping and exploration of non-living resources in the EEZ and in international waters. GSI has to date surveyed 18,48,318 km^2 out of 18,64,900 km^2 in the EEZ beyond the TW, and has surveyed 19,80,428 km^2 (EEZ + TW) out of a total of 20,14,900 km^2 (EEZ + TW).[1]

The following resources have been identified in the surveyed areas:

1. *Placer deposits*. These are accumulations of valuable minerals formed by sedimentation, and the survey has found two promising zones, viz. 210 km^2 on the west coast (off Aleppy-Quilon, Trivendrum-Kanyakumari and Ratnagiri) and 923 km^2 on the east coast (off Andhra and Orissa Coast), supposedly having rich placer deposits.

2. *Relict Marine Sand*. Surveys of various blocks off Kollam, Ponnani, Beypore and Chavakkad have confirmed the presence of relict marine sand in an area of 13750 km^2.
3. *Lime Mud Deposits*. These have been found at a depth of 180–1200 m off Gujarat coast and at depth of 100–200 m off Andhra Coast. These have also been found in the continental margin of Andaman and Nicobar Islands, Andhra and Gujarat coasts.
4. *Phosphatic Sediments*. These have been found at depths of 200–1000 m off Gujarat coast and at a depth of 100–200 m southeast of Chennai. These contain 15–20% phosphorus pentoxide (P_2O_5).
5. *Phosphorite nodules*. The concentration of P_2O_5 in nodules is between 15.6 and 18.6%, and is 9.8% in phosphate rich lime mud. Oolites and phosphate (> 5%) in lime deposits have been found off Vengurla. The nodules along with lime mud have been found at depths of 300–550 m off Gujarat coast. Phosphorite in nodules has also been found off Nagapattinam at depths of 45–412 m.
6. *Manganese Nodules*. Ferro-manganese encrustations have been located off Batti Malva in the Andaman Sea, and micro-manganese nodules have been found west of Lakshadweep at depths of 2800–4300 m.

India received rights to explore the ocean seabed for these nodules in 1987 and it has established two mine sites after exploring an area of approximately 4 million square miles. China too has been active in this region, and the China Ocean Mineral Resources Research and Development Association (COMRA) has been allowed to undertake PMS exploration in an area of 10,000 km^2 in the southwest Indian Ocean by the International Seabed Authority (ISA).

Other Programmes

The Government of India has commenced implementation of the Ocean Science and Surveillance (OSS) program, under the Ministry of Earth Sciences. The main aim of the OSS program as defined includes:[2] providing a suite of ocean information and advisory services (IAS) for the coastal population; promoting research for sustainable utilisation of marine living resources, and assessment of health of coastal waters of India; conducting multi-disciplinary surveys for coastal protection to adapt to natural and man-made disasters and steps to mitigate them; establishing and sustaining coastal and oceanic observation networks; and to forge cooperation with the countries of the South Asian region and the Indian Ocean Rim countries for capacity development and addressing common coastal issues.

Ocean Data Collection

Ocean data collection is undertaken by extensive utilisation of moored platforms. These include automatic weather stations, the High Frequency (HF) radar stations on the coast, an indigenous marine surveillance system, acoustic Doppler current profilers (ADCP) on the coast, tsunami warning buoys, tide gauge stations, wave rider buoys for wave parameter measurements, Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction (RAMA) moorings[3] and equatorial current meter moorings. Data collection is also carried out through drifting buoys known as profiler floats; important among these are the expendable bathythermograph and expendable conductivity, temperature and density recorders (XBT/XCTD) and Argo floats. Argo floats are part of an international collaboration.[4] These collect temperature and salinity profiles from the upper 2000m of the ocean.

The Ministry of Earth Sciences also provides various advisory services on oil spills, tsunami, forecast of ocean states, fishing zones and coral reef status. Studies are being carried out in areas such as erosion, shoreline vulnerability and marine living resources, and the marine ornamental fish breeding technology has been successfully implemented. Important indigenous ocean technologies developed include a Polar Remotely Operable Vehicle (PROVe), which can carry out exploration up to 500 m depth as well as in polar regions. Deep-sea technologies and the Ocean Mining Group at the National Institute of Ocean Technology, NIOT,[5] are developing a deep-sea mining system for harnessing resources from the ocean. An integrated mining system, which is helpful in the mining of nodules on the seabed and the design of ocean current turbines, has also been formalised. NIOT in association with M/s Keltron has developed an accelerometer-based vector sensor for measuring particle velocity and acoustic pressure.

India continues to make emphatic strides in the field of ocean sciences and technology, and the benefits are accruing to the coastal regions of India by enhancing their security, survivability and livelihood.

Maritime operations and information

Maritime operations cover under their ambit a large number of connected activities in addition to mapping and charting required for navigating the open seas. It requires a myriad of environmental information such as tides, current, weather, wind, depth, salinity, etc. In addition, it entails information regarding ports and harbours, dredging, navigation aids, waterways, restrictions in force and so on.

Advances in research and technology are facilitating an increased need for commerce and transportation in the maritime domain. These also help to address environmental issues as well as security concerns encountered in global commons and on the coasts. Safe and efficient conduct of maritime operations like marine transportation, search and rescue missions, and naval operations require enhanced forecasting of prevalent marine conditions as well as advance information about transient short-term local phenomena, like storms.

Maritime Domain Awareness and the Concept of Oceanic Domain Awareness

As a consequence, the maritime domain awareness (MDA) concept, for example, demands a much higher level of awareness than what is normally required in a conventional naval conflict. It implies that the goal of MDA is far more than simply looking for potential enemies in the maritime domain. MDA must therefore be exercised over all oceans worldwide, and should potentially cover all maritime interests that ultimately affect India. Putting in place an effective MDA is a herculean task viewing the range of potential security challenges and the large geographic area represented by the maritime domain.

It is opined that broadening of the sea horizon is required since the terms "sea watch/denial/control" are likely to expand and transform into "oceanic space watch/denial/control". The term oceanic space denial/control would embrace a cylindrical space in all three dimensions – that is, the sea surface; the atmospheric volume above and outer space at least up to low Earth-orbiting satellite heights; and the water volume down to the seabed and the seabed itself.

This premise implies that a broader oceanic horizon is in fact inclusive of not only an extensive and broader spatial operating arena, but also a much wider area below the surface to the seabed and above, up to the periphery of the atmosphere. Unless implications arising from this expansion are anticipated and factored in, technological forecasts themselves would trail behind the rapidly advancing pace of technology and the synergies being achieved due to harmonisation and adaptation of inter- and intrascientific fields. Therefore, it is imperative that holistic perspectives are developed in the area of information consciousness which includes the oceanic domain awareness as well as its relationship with a country's security and MDA.

Expanded awareness of the ocean environment for security operations requires improved capabilities in autonomous monitoring of desired ocean parameters in any location for extended time periods; fusion of multi-sensor data, including data from a robust, satellite-based global earth observation system; and numerical models to provide now-casts and forecasts for critical parameters. This will require advancing sensor and technology development, particularly for autonomous and persistent observations, as well as for long-term observing systems; expanding real-time or near-real-time data collection on environmental variables by incorporating observational capabilities of ships (e.g. fishing, cargo and passenger vessels); and enhancing automated and autonomous bottom-mapping capabilities for detection of any changes.

Thus, while the MDA focuses upon the maritime security environment specific to naval operations, the oceanic domain awareness (ODA) focuses upon the overarching knowledge of the oceanic environment. Both are technology intensive and require sophisticated sensors and computational capabilities. MDA has tactical, regional and strategic components, whereas the ODA has a strategic knowledge-based architecture. Both require elaborate data and an information-sharing interface with a myriad of agencies. The MDA primarily needs large inputs from commercial, intelligence and security agencies and the ODA from advanced research, academic and scientific communities. The ODA and MDA may become interactive parts of the proposed Indian Information Network (IIN), as depicted in Figure 1.

The IIN would be an all-encompassing information network with the Ministry of Defence (MoD) network embedded in it. The MoD network would include networks of all three services including the communication networks, data, storage, security, applications, user and source interfaces, etc., which would enable free flow of information. The IIN would have an interface with intelligence, surveillance and reconnaissance (ISR) sensors and data-processing network systems, which would transform raw sensor data into processed information. It would also contain interfaces with weapon platforms, weapons and sensors onboard the weapons themselves.

The Indian Navy Wide Network, as depicted in Figure 2, will have its interfaces with IIN, MDA, the MoD network, communication and video links, other civil and information networks, hardware, network security, applications, user interfaces, etc. It would have platforms as communication and navigation links, platforms as sensors, platforms as weapons (for anti-shipping, Anti Submarine Warfare [ASW], Mine

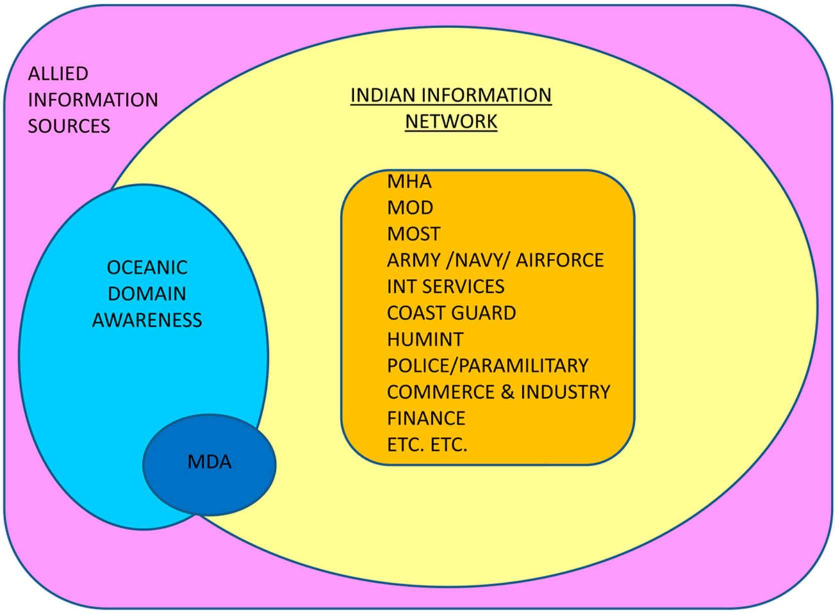

Fig. 1. The Indian Information Network (IIN) and Its Components.
Note: MHA-Ministry of Home affairs, MOD-Ministry of Defence, MOST-Ministry of Science and Technology, INT-Intelligence Services, HUMINT-Human Intelligence, MDA-Maritime Domain Awareness

Counter Measures [MCM], anti-air, special ops, etc.). The platforms themselves would have interfaces with weapon-borne sensors (radar, sonar, proximity fuse sensors, depth, speed, etc.). This type of network would have all users and sensors interconnected by a common network without any information intermediary or dependency on dedicated sensor to user circuitry. The IIN would provide an information-sharing architecture to enable network-centric operations.

Oceanic Information Consciousness Zones (OICZ)

As can be seen from the above configuration, setting up such an exhaustive and cohesive information-sharing network in India is a formidable task. Currently, many entities are setting up their parts of information networks, which will eventually be harmoniously interconnected. The allied information sources and ODA are interactively connected. The area which is relevant to this paper pertains to collating ocean science data

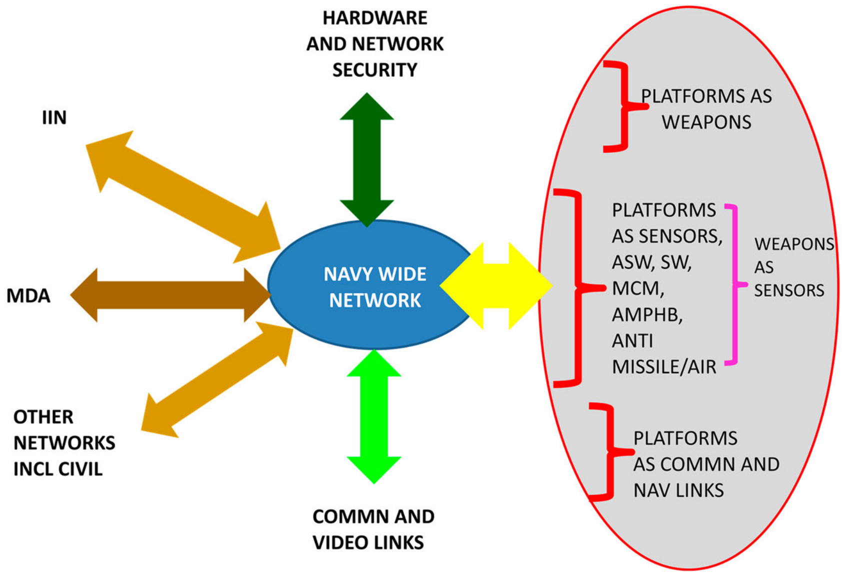

Fig. 2. Indian Navy Wide Network.
Note: ASW-Anti Submarine Warfare, SW-Surface Warfare, MCM-Mine Counter Measures, AMPHB-Amphibious, Anti Missile/Air, COMMN-Communication, NAV-Navigation Links, COMMN- Communication and Video links, IIN-Indian Information Network, MDA-Maritime Domain Awareness, INCL-Including Civil.

generated by friendly countries in the Indian Ocean Region. This forms the interlacing for the ODA and enhances the "ocean information consciousness zone" (OICZ) for India.

The ODA is defined as a comprehensive 3 Dimensions Plus (3D+) knowledge zone up to India's Exclusive Economic Zone (EEZ); the OICZ, on the other hand, is a collaborative approach at sharing oceanic information, processing it as required and archiving it for use at a later date. ODA can be established by a country individually, but OICZ requires the transfer of scientific knowledge and technology to the recipient nation. Benefits of ODA accrue to the nation whereas OICZ would empower the entire region, and both are strategic in nature. Figure 3 depicts the concept of a collaborative OICZ.

There are many challenges in the collection of data at sea as compared to land-based observatories. The sea presents a hostile and corrosive environment which corrodes sensors and damages related infrastructure.[6] It is impervious to radio waves and thus

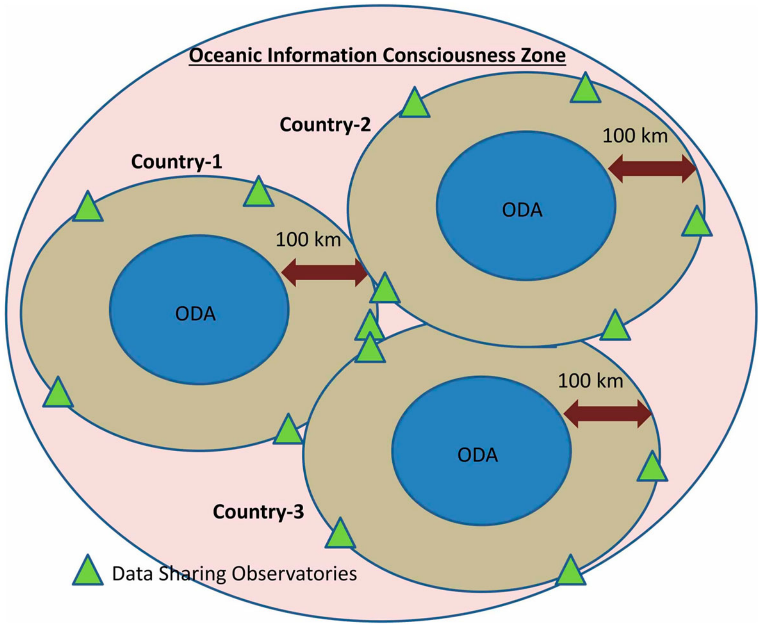

Fig. 3. Concept of Oceanic Information Consciousness Zone.
Note: ODA-Oceanic Domain Awareness

large volumes of it remain opaque to observations. High-resolution imagery at great ocean depths is not available, and the continuous availability of reliable data over prolonged periods is always a challenge. Marine growth and marine life interfere with the effective functioning of sensors and platforms, and providing continuous and reliable power to sensors at large distances and depths from the shore is a limiting factor.

Due to limitations of resources, it is not feasible for any single country to acquire all oceanic information and to safeguard, monitor and maintain the accompanying infrastructure at all times. It is also a daunting task for a country to acquire complete information, even in its immediate areas of interest (100 km beyond the EEZ in a three-dimensional space from 30,000 ft above the surface to 20,000 ft below the sea level). Therefore, it becomes essential to set up and nurture the extended OICZs amongst like-minded and friendly countries in the Indian Ocean Region (IOR). This benign approach would benefit the participating country by enriching its information in vital areas of not only security but also fisheries, ocean environment, seabed resources, marine bio-diversity, marine life and others. This in turn would enhance the productivity as well as the prosperity of the region.

India could facilitate the setting up of cabled ocean science observatories on the coast as well as at sea at distances up to 100 km or more beyond the EEZ of the coastal nation under bilateral information sharing agreements, as an addendum to various trade agreements, which India has with almost all of the IOR nations.[7] The suggested areas which the technologies would cover under this arrangement would be: robotics including autonomous underwater vehicles; smart sensors; data storage, data processing and transfer; advanced computation, modeling and forecasting; underwater communications; seabed mining; surveys of fisheries and marine life; marine support structures, etc.

The cabled observatories have the advantage of a continuous power supply and the availability of large bandwidth. Commercial-off-the-shelf (COTS) submarine telecommunications cables can supply power and can transmit 1 Tb/s on a single cable. However, an ocean observatory should be much more rugged than a land-based one, and the reliability of performance and ease of maintenance are challenges which need to be overcome for a good design. The detailed technical requirements for the *Neptune* cabled observatory provide a good guideline.[8] Its main features are: lifetime of at least 25 years; requirement of dynamic resource directability; expansion capability by addition of nodes; upgradability in future; reliability in being able to send data to/from any instrument from/to shore and/or from/to other nodes, exclusive of instrument functionality; and that it would have functionality and performance to support future instrumentation.

Conclusion

India has made significant progress in its quest for understanding the Indian Ocean, both near the coasts and at large distances from the TW. It has a rich bank of oceanic knowledge and technologies, which it can share with nations in the IOR. To accrue mutual benefits, India can also collaborate in setting up ocean observatories on the coasts, in and around the EEZs, and in areas beyond the EEZs of the IOR countries. The information and knowledge so acquired and shared would, in times to come, help increase scientific inputs for the Indian Ocean and would make it safe and environmentally sustainable for maritime operations, and economically profitable for the IOR.

Notes

1. Marine and Coastal Survey, 2012, Geological Survey of India, Ministry of Mines, Government of India. http://36igc.org/files/Marine_Coastal_Survey.pdf (accessed August 21, 2015).

2. Vision and Prospective Plan for 10 years in Ocean Sciences & Services, March 2010 Ministry of Earth Sciences, Government of India. http://moes.gov.in (accessed August 10, 2015).
3. Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA), n.d. National Oceanic and Atmospheric Administration. http://www.pmel.noaa.gov/tao/rama/# (accessed August 16, 2015).
4. Argo, How Argo Floats Work, n.d. University of California, San Diego. http://www.argo.ucsd.edu/How_Argo_floats.html (accessed August 12, 2015).
5. Deep Sea Technologies, n.d. National Institute of Ocean Technology. https://www.niot.res.in/ (accessed August 8, 2015).
6. John R. Delaney and Roger S. Barga, "A 2020 Vision for Ocean Science," in *The Fourth Paradigm: Data-Intensive Scientific Discovery*, ed. Tony Hey, Stewart Tansley, and Kristin Tolle. http://research.microsoft.com/en-us/collaboration/fourthparadigm/4th_paradigm_book_part1_delaney_barga.pdf (accessed August 13, 2015).
7. International Trade-Trade Agreements, n.d. Ministry of Commerce and Industry, Government of India, http://commerce.nic.in/trade/international_ta_current_details.asp (accessed August 21, 2015).
8. J.R. Delaney et al., "NEPTUNE: Real-time ocean and earth sciences at the scale of a tectonic plate," *Oceanography*, 13 (2000): 71–83.