HYDROGRAPHY FOR FURTHERING INDIA'S INFLUENCE IN INDIAN OCEAN AND BEYOND

DISSERTATION SUBMITTED TO PUNJAB UNIVERSITY, CHANDIGARH IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR AWARD OF DEGREE OF MASTER OF PHILOSOPHY IN SOCIAL SCIENCES

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CERTIFICATE

I have the pleasure to certify that Captain Vishal Sharma has pursued his research work and prepared the present dissertation titled "Hydrography for furthering India's influence in Indian Ocean and beyond" under my guidance and supervision. The dissertation is the result of his research and to the best of my knowledge, no part of it has earlier comprised any other monograph, dissertation or book. This is being submitted to the Punjab University, Chandigarh for the degree of Master of Philosophy in Social Sciences in partial fulfilment of the requirement for the Advanced Professional Program in Public Administration (APPPA) of Indian Institute of Public Administration (IIPA), New Delhi.

I recommend that the dissertation of Captain Vishal Sharma is worthy of consideration for the award of M Phil degree of Punjab University, Chandigarh.

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LIST OF ABBREVIATIONS

1.	ABLOS	Advisory Board on Laws of the Sea
2.	ADB	Asian Development Bank
3.	ADCP	Acoustic Doppler Current Profiler
4.	ADLS	Automated Data Logging System
5.	AIS	Automatic Identification System
6.	ALH	Advanced Light Helicopter
7.	AMHS	Admirality Manual of Hydrographic Surveying
8.	APEC	Asia-Pacific Economic Cooperation
9.	ASV	Autonomous Surface Vehicles
10.	ATG	Automatic Tide Gauge
11.	AUV	Autonomous and Unmanned Vehicles
12.	BIWTA	Bangladesh Inland Water Transport Authority
13.	BNHD	Bangladesh Navy Hydrographic Department
14.	BNHOC	Bangladesh Navy Hydrographic and Oceanographic Center
15.	BNHS	Bangladesh Navy Hydrographic School
16.	CATZOC	Category Zone of Confidence
17.	CHS	Canadian Hydrographic Service
18.	CHSVs	Catamaran Hull Survey Vessels
19.	CLCS	Commission on the Limits of the Continental Shelf
20.	CRZ	Coastal Regulatory Zone
21.	CSB	Crowd Sourced Bathymetry
22.	CSBWG	Crowd Sourced Bathymetry Working Group
23.	CTD	Conductivity, Temperature, Depth sensor

24.	CZM	Coastal Zone Management
25.	DVL	Doppler Velocity Log
26.	DGPS	Differential Global Positioning System
27.	DCDB	Data Centre for Digital Bathymetry
28.	DP	Dynamic Positioning
29.	ECDIS	Electronic Chart Display and Information System
30.	ENC	Electronic Navigation Chart
31.	EEZ	Economic Exclusive Zone
32.	GCC	Gulf Cooperation Council
33.	GEBCO	General Bathymetric Chart of the Oceans
34.	GIHS	General instructions for hydrographic surveyors of Admiralty
35.	GMDSS	Global Maritime Distress and Safety Services
36.	GoI	Government of India
37.	GoM	Government of Mauritius
38.	GPS	Global Positioning System
39.	HADR	Humanitarian Aid and Disaster Relief
40.	HDRTN	Hydrographic Department, Royal Thai Navy
41.	HPD	Hydrography Product Database
42.	HQAIs	Hydrographic Quality Assurance Instructions for Admiralty Surveys
43.	HQIDS	Headquarters, Integrated Defence Staff
44.	ICG	Indian Coast Guard
45.	IDSA	Institute of Defence Studies and Analyses
46.	IFMS	Interferometric sonar
47.	IHB	International Hydrographic Bureau

48.	IHO	International Hydrographic Organisation
49.	IHPT	Portuguese Hydrographic Institute
50.	I-MaGIC	Indonesian Marine Geospatial Information Center
51.	IMO	International Maritime Organization
52.	IN	Indian Navy
53.	INAHINA	Mozambique National Institute of Hydrography and Navigation
54.	INHC	Iranian National Hydrographic Committee
55.	INHD	Indian Naval Hydrographic Department
56.	INHO	Indian Naval Hydrographic Office
57.	INHTT	Indian Naval Hydrographic Training Team
58.	INS	Indian Naval Ship / Inertial Navigation Sysytem
59.	INSPIRE	Innovation in Science Pursuit for Inspired Research
60.	INT Charts	International Series Charts
61.	IOC	Intergovernmental Oceanographic Commission
62.	IONS	Indian Ocean Symposium
63.	IOR	Indian Ocean Region
64.	IRCC	Inter-Regional Coordinating Committee
65.	ISV	Inshore Survey Vessel
66.	ITEC	Indian Technical and Economic Cooperation
67.	KHS	Kenya Hydrographic Service
68.	KPA	Kenya Ports Authority
69.	KPMG	Klynveld Peat Marwick Goerdeler
70.	LABS	Laser Airborne Bathymetry
71.	LADS	Laser Airborne Depth System (SBL) LBL
72.	LBL	Long Base Line

73.	LIDAR	Light Detection and Ranging
74.	MBES	Multibeam echo sounders
75.	MCPI	Ministry of Construction and Public Infrastructure
76.	MCPP	Maritime Capability Perspective Plan
77.	MEA	Ministry of External Affairs.
78.	MHS	Mauritius Hydrographic Service
79.	MLHSSD	Ministry of Lands, Housing and Human Settlements Development
80.	MN	Myanmar Navy
81.	MNDF	Maldives National Defence Force
82.	MNHC	Myanmar Naval Hydrographic Centre
83.	MSD	Military Survey Department of UAE Armed Forces
84.	MSDI	Marine Spatial Data Infrastruture
85.	MSIS	Maritime Safety Information Services
86.	MSP	Maritime Security Policy
87.	NARA	National Aquatic Resources and Research Agency
88.	NCWG	Nautical Cartography Working Group
89.	NFT	National Flag Tonnage
90.	NIH	National Institute of Hydrography
91.	NIOHC	North Indian Ocean Hydrographic Commission
92.	NIPWG	Nautical Information Provision Working Group
93.	NOAA	National Oceanic and Atmospheric Administration
94.	OJT	On job training
95.	OSD	Overseas Deployment
96.	PCA	Primary Charting Authority
97.	PWC	Price Water House Cooper pvt Ltd

98.	PWGCA	Permanent Working Group on Cooperation in Antarctica
99.	QA/QC	Quality Assurance and Quality Check
100.	RAN	Royal Australian Navy
101.	RENC	Regional ENC Coordinating Centre
102.	RHCs	Regional Hydrographic Commissions
103.	RNO	Royal Navy of Oman
104.	ROVs	Remotely operated Vehicles
105.	SAIHC	Southern Africa and Island Hydrographic Commission
106.	SANHO	South Africa National Hydrographic Office
107.	SAR	Synthetic Aperture Sonar
108.	SBES	Single Beam Echo Sounder
109.	SBL	Short Base Line
110.	SBS	Swath Bathymetric Systems
111.	SCG	Seychelles Coast Guard
112.	SDB	Satellite Derived Bathymetry
113.	SHOALS	Scanning Hydrographic Operation Airborne
114.	SLN	Sri Lanka Navy
115.	SMEs	Subject Matter Experts
116.	SMSA	Seychelles Maritime Safety Administration
117.	SoK	Survey of Kenya
118.	SOLAS	Safety of Life At Sea Convention
119.	SONAR	sound navigation ranging
120.	SPWG	Strategic Planning Working Group
121.	SSS	Side Scan Sonar
122.	SUMATRA	Surface and Marine Transport Regulatory Authority

123.	SVP	Sound Velocity Profiler
124.	THU	Total Horizontal Uncertainty
125.	TMS	Tether management system
126.	TPA	Tanzania Ports Authority
127.	TQM	Total Quality Management’
128.	TSS	Traffic Separation Scheme
129.	TVU	Total Vertical Uncertainty
130.	TWLCWG	Tides, Water Level and Currents Working Group
131.	UKHO	United Kingdom Hydrographic Office
132.	UN	United Nations
133.	UNCLOS	United Nations Convention on the Law of the Sea
134.	UNCTAD	United Nations Conference on Trade and Development
135.	UNDP	United Nations Development Programme
136.	UNESCO	United Nations Educational, Scientific and Cultural Organization
137.	USBL	Ultra Short Baseline
138.	USI	United Services Institute
139.	USV	Unmanned Surface Vehicles
140.	WEND	World Electronic Chart Data Base

CHAPTER 1

INTRODUCTION AND RESEARCH METHODOLOGY

"The oceans will continue to be the highways of trade in the foreseeable future. The oceans will continue to be the meeting ground of nations, with their interests and ideologies in accord and sometimes in conflict with one another. The oceans will constitute the hope of mankind in search of new sources for sustenance."[1]

\- *Admiral SN Kohli*
Former Chief of Naval Staff, Indian Navy

1.1 **Maritime Strategy**. "Maritime security is a 'subset' of National Security, but it also relates to a very wide spectrum of national interests. At one end are those linked to civilian facets like mercantile trade, shipbuilding, resource exploitation, law-enforcement and preservation of marine environment. At the other extreme, are military strategic dimensions to preserve state's survival interests. A state's ability to use the sea to further these interests is reckoned in terms of its Maritime Power, of which, Naval Power is the key constituent"[2]. The national interests have shifted towards seas and oceans worldwide in view of the geo-politics and global economy. The naval power of a nation is a comprehensive 'collective capability'[3] which can achieve mastery over seas and oceans. This capability must be able to accomplish the task in the varied spectrum and roles defined by the dynamic nature and character of the seas and oceans.

1.2 "A nation's interaction with its peers in the global community of nations is determined by its foreign policy. If the instruments of the nation's foreign policy are wisely chosen and skilfully applied in a timely enough fashion, the direct application of military force is seldom required. Therefore, the main task of armed forces is not to

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[1] SN Kohli, Sea Power and The Indian Ocean. New Delhi: Tata McGraw-Hill Publishing Company Limited, 1978. p 23

[2]Gurpreet S Khurana. Maritime Forces in Pursuit of National Security, Policy imperatives for India. Shipra, Institue of Defence Studies and Analyses, 2008.p i

[3] Ibid p ix

fight wars but to prevent them. Navies worldwide, unlike the Armies and the Air Forces are ideally suited to support the foreign policy objectives of the country and therefore naval diplomacy gains importance. Navies offer a wide range of diplomatic instrument for use in normal peacetime, in times of strain and during crisis"[4].

1.3 The Indian Navy is the primary means by which India ensures the use of the seas for her own purpose, simultaneously safeguarding the waters from prejudicial use by an adversary. The Indian Navy's capability is being built up in a manner that it can project power; maintain deterrence in a possible conflict to ensure peace. "The sea lines of communication passing through our region are critical for our economic growth and to the global community. Smaller nations in our neighbourhood as well as nations that depend on the waters of the Indian Ocean for their trade and energy supplies have come to expect that the Indian Navy will ensure a measure of stability and tranquillity in the waters around our shores. Ensuring good order at sea is therefore a legitimate duty of the Indian Navy. This task will require enhanced capabilities, cooperation and interoperability with regional and extra regional navies"[5].

1.4 **Roles of the Indian Navy.**[6] The full range of operations in which a nation's naval forces may be involved is vast, ranging from high intensity war fighting at one end to humanitarian assistance and disaster relief operations at the other end. This broad continuum of operations can be broken down into distinct roles; the four main roles envisaged for the IN are Military, Diplomatic, Constabulary and Benign. The Diplomatic, Constabulary and Benign roles are essentially peace-time tasks.

(a) **Military.** The Military Role is the traditional role of navies and encompasses all situations which require the use of military force. This is principally a war-time task.

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[4] Cdr Venugopal, Cdr Surendra Ahuja and Cdr Surendra Singh. "Indian Navy's Role As An Instrument Of India's Foreign Policy" http://indiannavy.nic.in/nott_winner_2001.pdf. (accessed on 28 Jul 11).

[5] Sureesh Mehta (former Chief of Naval Staff) Freedom To Use The Seas. India's Maritime Military Startegy. New Delhi: Integrated Headquarters Ministry of Defence (Navy), May 2007.p iv

[6] Maritime Doctrine and Concept Centre. Indian Maritime Doctrine. Mumbai: Integrated Headquarters Ministry of Defence (Navy), 2009.pp71-91

(b) **Diplomatic.** The Diplomatic Role involves the use of maritime forces to support national political objectives and foreign policy, and assumes the availability of force to back up and support diplomatic efforts at various levels.

(c) **Constabulary.** Maintaining 'good order at sea' is the primary objective of the Constabulary Role;

(d) **Benign.** Humanitarian Assistance and Disaster Relief (HADR) operations are undertaken under the Benign Role.

1.5 **Statement of the Problem**. The statement of the problem is as under:-

(a) Hydrography is infrastructurally intensive, technologically driven and prohibitively expensive. The upshot is that there are very few nations, especially in our region, who are practicing it. India with its vast hydrographic resources and highly trained manpower is well poised to make a global impact.

(b) The niche capabilities of Indian Navy, especially Hydrographic Surveying capability in benign and diplomatic roles can enhance our foot print in the Indian Ocean Region (IOR) and can also win goodwill across the oceans.

(c) This paper seeks to study latest trends in the field of hydrography and also to examine the hydrographic capabilities of Indian navy and its employment as an important peace time diplomacy/strategic tool for furtherance of our national interests in the Indian Ocean Region and beyond.

1.6 **Research Objectives**. The objectives of research are as under:-

(a) To study the importance of hydrography, the application and interpretation of hydrpgraphic data in various specialized fields for national development.

(b) To evaluate the Hydrography capability of Indian Navy, Present setup, its expertise and employment in Indian Ocean Region as a strategic tool.

(c) To examine existing Regional Cooperation initiatives in hydrography and way ahead for enhancing India's footprint at international level to foster diplomatic/ strategic gains for India.

1.7 **<u>Research Strategy and Design</u>**. Despite having one of the largest Naval Hydrographic Service, India is dependent on foreign sources for most of its capabilities. If India is to be self-reliant in this very important field, the present state of affairs has to change and we have to break the shackles of old mindsets and prejudices. It is therefore, proposed to analyse the problem areas existing and identify the way forward for development of in-house expertise. Another important aspect is further encouraging private sector to participate equally in hydrographic capacity building of our country.

(a) **<u>Research Strategy</u>**. The research strategy is both qualitative and quantitative in approach.

(b) **<u>Research Design</u>**. The research design is descriptive and exploratory in nature based on the following:-

(i) Global and latest trends in the field of Hydrography.

(ii) Critical short, medium and long-term technologies that are essential to be imbibed in a time bound manner.

(iii) Int’l Hydrographic Cooperation and capability gaps in IOR.

(iv) Futuristic roles of hydrography in Indian Ocean Region and its employment for enhanced foothold.

(v) Importance and economic impact of Hydrography.

(vi) Present Hydrographic Setup in Indian Navy, its strengths and weaknesses.

(vii) Synergy between stakeholders.

1.8 **Rationale of the Study**. The aim of this paper is to study the latest trends in the field of Hydrography and the opportunities that could be harnessed from hydrography for furthering India's influence in the world giving impetus on training and international/ regional cooperation as an important peace time diplomacy tool. This paper will also examine the existing foreign cooperation initiatives in hydrography and recommend way ahead for enhancing India's footprint at international level to foster tangible gains. The niche capabilities of Indian Hydrographic surveying capability in benign and diplomatic roles will enhance our foot print in the Indian Ocean Region and will win goodwill across the oceans. The study will concentrate on importance of hydrography, the application and interpretation of hydrographic data in various specialized fields for national development. Hydrography capability of India, its expertise and employment in Indian Ocean region as a strategic tool.

1.9 **Research Question**. The major research questions that the study intends to address are as follows:-

(a) Importance and specialised applications of Hydrography.

(b) What are the latest trends in the field of Hydrography across the globe and measures required to harness them?

(c) What are the credentials and strength areas of our Hydrographic capabilities and measures to further bolster them?

(d) Cooperation with other regional states so far in the field of Hydrography and what are the measures required to further strengthen it?

(e) What are the futuristic roles of Hydrography in region towards furtherance of our national interest?

(f) What are the major changes required in the present setup/ approach.

1.10 **Research Limitations/Delimitations**. Several limitations of the research process are anticipated. These limitations are as follows:-

(a) Information and data on defence and technical capabilities due to security issues.

(b) Availability of policy makers and key stake holders (Govt of India, Indian Navy and Industry captains) for interview.

(c) Limited availability of detailed data due to sensitivity of the subject matter.

(d) Availability of systematic and detailed data in the public domain.

(e) The papers, documents and manuals available on the topic are relatively old and therefore it would be difficult to relate it with the new technologies, equipments and procedures.

1.11 **Research Methodology**. The methodology proposed to be adopted is exploratory in nature and comprises of the following:-

(a) Critical review of secondary literature.

(b) Information collated from the secondary source will be interpreted and analysed to impart a logical flow of thought & arrive at specific facets of the problem.

1.12 **Data Sources**

(a) Secondary data available in public domain i.e. relevant books, reports released by Govt of India, various other organisations/agencies viz, Indian Navy, INHD, IHO, IDSA, USI journals, private sector consultancy companies such as PWC, KPMG etc.

(b) Secondary data available in periodicals, national & international journals, published articles in newspapers & magazines, internet sites, website of the Ministry of Defence etc.

(c) Discussion with policy makers of Govt of India, Indian Navy and major players in the field.

(d) Inferences based on exploratory research for analysis of the information and formulation of views.

1.11 **Literature Review**. "The task domain of the navy has expanded from traditional 'hard' security to 'softer' issues like economics and environment security that are closely linked to the use of oceans"[7]. The role of navy has grown out of the traditional maritime security agency and has a wider role to play influencing all activities at sea which would influence and impact economy and geo-politics. "Hence, our strategy stresses the need for adequate forces, in concert with our Coast Guard, for undertaking the constabulary role in our maritime area of interest. Apart from combating piracy and terrorism at sea, this also includes responsibilities of surveying the waters around us, providing SAR facilities to those in distress, coordinating navigational warnings over a vast oceanic area and a myriad of minor but vital tasks that keep the global maritime-related industry, and the global economy, in good health. These facets of our strategy make the peace time objectives abundantly clear. Our role in the 2004 Tsunami relief operations is a classic example of the positive power of navies in 'winning friends and influencing people.' The thousands of people whose lives were touched by the assistance provided by Indian seamen remains etched in their mindsets"[8].

(a) **Admirality Manual of Hydrographic Surveying (AMHS), 1965.** This document is considered to be akin to Bible for all the Hydrographers. This manual was first published by the British Hydrographic Services in year 1965 and thereafter it has been kept relevant by way of the amendments. This book divided into various parts and discusses various methods of Hydrographic data collection using the then existing equipment.

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[7] Gurpreet S Khurana.Op.cit. p viii

[8] Sureesh Mehta. Loc.cit.

This however remains silent on the advent of latest state of art hydrographic equipment and their exploitations.

(b) **General instructions for hydrographic surveyors of Admiralty (GIHS), 1982.** The document which deals in the procedures of data analysis, quality control and rendering of various reports was first published by the Hydrographic Service of Great Britain in 1982. The procedures discussed for data analysis, QA/QC and reporting are at places, manual, old and time consuming. The book does not discuss the use of latest technology equipment, their QA/QC procedures and capabilities.

(c) **Manual on Hydrography , IHO Publication, 2005.** The International Hydrographic Organisation (IHO) Manual on Hydrography general objective is to provide knowledge on the concepts involved in hydrography as well as guidance to plan and execute hydrographic surveys. The Manual is considered to be a professional guide for hydrographic surveyors and a tool for teachers and students involved in hydrographic courses or programs. In 2004 a meeting between the member states of IHO took place to review the result obtained and decide on a draft version of the Manual. After collecting comments from these member states, the final version was prepared and the IHO Manual on Hydrography was published in year 2005. The content of this Manual is divided into following seven chapters:-

(i) Chapter 1 explains principles of hydrographic surveying, including its specifications

(ii) Chapter 2 refers to positioning

(iii) Chapter 3 to refers to depth determination, including both the principles and techniques used

(iv) Chapter 4 provides information on sea floor classification and object detection

(v) Chapter 5 refers in particular to water levels and flow

(vi) Chapter 6 is devoted to topographic surveying applied to hydrography

(vii) Chapter 7 provides, in a structured way, complete details on hydrographic practice

(d) **<u>Hydrographic Quality Assurance Instructions for Admiralty Surveys (HQAIs), 2003.</u>** Throughout its history the Surveying Service has been innovative and ready to exploit the challenges that new technology or organisational methods bring so that the needs of the Royal Navy and other mariners can be met effectively and efficiently. One new method is 'Total Quality Management' (TQM) a management concept that was developed in both the public and private sectors in early and late 90s. Hydrographic Quality Assurance Instructions (HQAIs) were published by the British Hydrographic Service in 2003 and are one outcome of the TQM approach to assuring the quality of Admiralty Surveys, an approach that should be seen as building on the past reputation of the Surveying Service earned by the dedication and hard work of its surveyors. The purpose of HQAIs is to provide the instructions and procedures for the conduct of Admiralty Surveys. In this book, both the terms 'Admiralty Surveys' and 'hydrography' are given a wide interpretation. They include not only the surveys conducted for the improvement of navigation charts and publications but all the hydrographic, oceanographic and geophysical data needs of the Fleet. A classified addendum to HQAIs, issued separately, includes instructions and procedures for surveys conducted to support amphibious operations, mine-warfare, rapid environmental assessment, geophysical and oceanographic observations

(e) **<u>Indian Maritime Doctrine, Indian Navy (2005-2009).</u>** Present international security scenario is in a state of flux, and is likely to remain characterised by uncertainty and ambiguity in the coming decade. However, it does have two concrete indicators. The first is the ongoing geo-political movement under the effects of globalisation, leading to the imperative to safeguard our interests both by unilateral deterrence and by multilateral diplomacy. Secondly, the focus of activity is steadily shifting from the West towards Asia. Both would have major ramifications for countries, particularly in Asia. Amidst the continuing changes in the regional and global strategic scenario, India has also been undergoing significant changes. In pursuit of its core national aim of unhindered economic and socio-political development of its citizens, India has made strides in these spheres. In the coming decade, the challenges can be expected to rise, both from within and from without, in meeting the legitimate, growing aspirations of our mostly youthful populace. Towards this, India would need to maintain an external environment that is friendly, with due security and safety for her citizens to freely pursue national and individual development and growth. The maritime environment in our areas of interest, and the basic attributes and characteristics of warships, enable multiple roles and objectives for the Indian Navy, ranging across military, diplomatic, constabulary and benign. In keeping with the changes in the geo-political environment and national security imperatives, the Indian Navy would have to prepare itself for increased effort and ability in discharging these roles, with a larger canvas of objectives and missions that may be necessitated. Many of the threats to safety, stability and security at sea are today common to most states, especially in the IOR. This emphasises the need for a greater degree of coordination and cooperation in keeping with the need for respective national growth. The Indian Navy would need to develop the ability to coordinate and cooperate with regional and other navies for meeting challenges to international law, maritime safety and security on the 'great common', and in response to humanitarian disasters. The maritime doctrine is aimed at providing this base, by defining and describing the core, underlying concepts governing the scope and use of maritime power. This would, in turn, enable related doctrines on the various aspects of development, deployment and employment of maritime power in pursuit of India's core national interests. The Indian Maritime Doctrine is the capstone doctrinal publication of the Indian Navy, which is aimed at not just the professional sea warrior, but also at the thinker, planner, supporter and stakeholder amongst the Navy, other armed forces, government, think-tanks, media and the larger public of India.

(f) **Freedom to Use the Seas. India's Maritime Military Strategy, 2015**.

The previous publications on the subject articulated the Navy's maritime strategic outlook, defined the parameters of its employment, and provided overarching guidance for its evolution as a combat force. They, however, needed periodic review to continue reflecting prevailing circumstances and remaining contemporary and relevant. Such an exercise became necessary owing to significant developments of the past decade that affect India's maritime security and the role of her Navy. This document, published in 2015, covers a wide canvas. It seeks to provide readers in the Indian Navy, Indian Coast Guard, other maritime agencies and Armed Forces, as well as the Government and informed public, an insight into the rationale for strengthening India's maritime security in the coming years. It has been compiled through an iterative and inclusive process, eliciting inputs from the Indian Army, Indian Air Force (IAF), Headquarters Integrated Defence Staff (HQIDS), Indian Coast Guard (ICG), several defence related 'think tanks', and a large number of acknowledged experts in maritime affairs within and outside the Navy. The document also provide strategic guidance for the growth, development and deployment of the Navy in the coming years, and may need further review and retuning as circumstances and conditions change and evolve.

(g) **Gurpreet S Khurana, 2008**. "Maritime Forces in Pursuit of National Security, Policy imperatives for India", the book was published by Institute of Defence Studies and Analyses (IDSA) in year 2008. The growing interest of nations in the ocean-realm has become discernible in recent years, leading to an increased significance of maritime security. This is particularly relevant to India, whose vital stakes are expanding beyond its terrestrial confines. How has this increased the responsibility of Indian maritime forces? Can we expect these forces to satiate national-security interests beyond maritime affairs? What approach and capabilities are needed for this? This book touches upon all the above issues.

(h) **B Arunachalam, 2007.** Prof Arunachalam in Part I of this book titled "Navigational Hazards, Landmark and Early Charting Special Study of Konkan and South Gujarat" deals with numerous seen and unseen underwater hazards in near shore coastal waters and river mouths along the Indian coast. These have been recognised by Indian seamen since early days. This recognition is perfected with the aid of traditional landmarks named in local sea dialects and now - a - days with modern landmarks like lighthouses and helps them in steering a safe passage through difficult waters, in reaching a landing site or ports. This fund of knowledge led to visual sketching of the features thus becoming a forerunner to early charting, standardised in later colonial days though Admiralty Charts and the present Naval Hydrographic Charts. The Part II of this book jointly authored by Mrs Mary Edward and Dr Sachin Pendse is a special study of the coasts of Konkan and South Gujarat, their submarines morphology, littoral circulation pattern and sailing hazards as specific illustrations of the discussions in the first part.

(j) **Dr Manoshi Bhattacharya, 2004.** This book, authored by Dr Manoshi Bhattacharya is dedicated to the spirit and determination of the Hydrographers and Marine Cartographers who have stood their place in the history of India', is very much more than a history of the Hydrographic Department. It begins with descriptions of the earliest known voyages across the Indian Ocean and adjacent seas from the 15th century onwards when trading vessels from the newly established British East India Company began arriving on the coast of India at the beginning of the 17th century. The book highlights the survey efforts and the survey works undertaken by the British Hydrographers in India pre independence. It also carries certain archived early marine charts of India. As the surveying tasks increased year by year the Service had been making do with converted vessels, but in 1964 the first vessel to be built in India for hydrographic and oceanographic work, INS Darshak was commissioned. From then on the reader will find magnificent photographs of new survey ships built in India, including seven vessels of the Sandhayak class being commissioned. The book thereby gives us a fantastic insight into the history of Naval Hydrography in India and how has it evolved through these years to be a service to recon with.

(k) **Rahul Roy Chaudhury, 1999**. The author in his article on the issue of Indo-Pakistani dispute over Sir Creek in the Journal of Indian Ocean Studies has examined the maritime security and the role of Hydrography. The term maritime security represents the broadest approach to issues and aspects which pertain to the sea and have an important bearing on the country's security. The volume generates a fuller understanding of the different aspects of the maritime dimensions of India's security. As the seas of peninsular India and the Indian Ocean become more important than even before to the security of the country, it is imperative to examine the maritime dimensions of Indian security in a comprehensive manner. India's Maritime security provides, for the first time, a holistic assessment of the economic, political, and military aspects of India's maritime security. The term maritime security is defined as comprising those issues which pertain to the sea and have a critical bearing on the country's security. These include seaborne trade and commerce in energy resources, the management of living and non-living marine resources, the delimitation of international seaward boundaries, and the deployment and employment of naval and military forces in the Indian Ocean. This book also examines the importance of dealing effectively with the compulsions and complexities of India's maritime security which necessitates a sophisticated and often complicated, interplay of the country's economic, foreign, and defense polices. The book also recommends that it is imperative to formulate a national Maritime Security Policy (MSP). The implementation of such a policy will eventually lead to the development of a much-needed maritime strategy for the country.

CHAPTER 2

LATEST GLOBAL TRENDS IN HYDROGRAPHY

"Once a new technology rolls over you, if you're not part of the steamroller, you're part of the road."

– Stewart Brand

2.1 The history of hydrographic surveying dates almost as far back as that of sailing. For many centuries, a hydrographic survey required the use of lead lines with depth markings attached to lead weights to make one end sink to the bottom when lowered over the side of a ship or boat and sounding poles, which were poles with depth markings which could be thrust over the side until they touched bottom. In either case, the depths measured had to be read manually and recorded, as did the position of each measurement with regard to mapped reference points as determined by three-point sextant fixes. The process was labour-intensive and time-consuming and, although each individual depth measurement could be accurate, even a thorough survey as a practical matter could include only a limited number of sounding measurements relative to the area being surveyed, inevitably leaving gaps in coverage between single soundings[9].

2.2 We have progressed a lot since then. It's often a cliché to say that everything offshore has changed since the introduction of GPS, but there have certainly been many changes since back then in the 1980s. The other obvious transformational technology has been computers and computer processing that, like the rest of the world, has totally and radically changed our lives. It didn't happen immediately in the ultra-conservative environment of hydrography and offshore surveying. However, it's clear when comparing mid-20th century surveying with today, that they have totally and fundamentally impacted our projects. Nowadays, such technologies are often taken for granted, but whilst it's totally clear they have been adopted and are omnipresent in our

[9] https://en.wikipedia.org/wiki/Hydrographic_survey

working lives, what lessons can we take when considering today's technical developments, revolutions and the ever-evolving trends?

2.3 The development of the usage of acoustic technology to map the sea bed transformed the entire philosophy of how a hydrographic survey is undertaken. The next major breakthrough was advancement in technology which used the penetration power of Electro-magnetic waves in a water column to gather bathymetric data. This technology has significantly increased our capability in mapping shallow water areas. In today's era with major advancements taking place in the field of Robotics, Autonomous and Unmanned vehicles have completely transformed hydrographic surveying practices.

2.4 Thus in almost less than a century we have come a long way from using hand lead lines to deploying autonomous unmanned vehicles, airplanes and even satellites to map our sea floor efficiently. The following latest global trends in Hydrography are elaborated in the subsequent paragraphs:-

(a) Swath Bathymetric Systems (SBS)
(b) Synthetic Aperture Sonar (SAR)
(c) Autonomous and Unmanned Vehicles (AUV)
(d) Scanning Hydrographic Operation Airborne (SHOALS)
(e) Satellite Derived Bathymetry (SDB)
(f) Crowd Sourced Bathymetry (CSB)

2.5 **Swath Bathymetric Systems**. A "swath-sounding" sonar systems is used to measure the depth in a swath at right angles to the direction of motion of the transducer head. As the head moves forward, these profiles sweep out a ribbon-shaped surface of depth measurement, known as a swath. Current swath sounding systems utilize two differing technologies to achieve bathymetry measurements across a "swath" of the sea floor:-

(a) Beam forming (Multi-Beam Echo Sounders)
(b) Interferometry or Phase Discrimination Sonars

2.5.1 Both of these above techniques have their merits. Multibeam echo sounders (MBES) collect bathymetric soundings in a swath perpendicular to the ship track by electronically forming a series of transmit and receive beams in the transducer hardware which measure the depth to the sea floor in discrete angular increments or sectors across the swath. Various transmit frequencies are utilized by different MBES systems depending on the sea floor depth. For example, low frequency (12 kHz) systems can collect swath soundings at full ocean depths, up to 10,000 meters. Whereas, high frequency MBES systems (300+ kHz) are utilized for collecting swath bathymetry in depths of 20 meters or less.

2.5.2 In contrast, the term "interferometry" is generally used to describe swath-sounding sonar techniques that use the phase content of the sonar signal to measure the angle of a wave front returned from a sonar target. When backscattered sound energy is received back at the transducer, the angle the return ray of acoustic energy makes with the transducer is measured. The range is calculated from two-way travel time. The angle is determined by knowing the spacing between elements within the transducer (the phase difference of the incoming wave front, and the wavelength). Interferometric sonar (IFMS) is an emergent technology that may provide significant advantages. IFMS provides co-located bathymetry and imagery enabling advanced display and quality control capabilities with seafloor datasets. IFMS systems are not beam-forming, but accurately measure depths at precise locations on the seafloor via the use of exactly spaced phase differencing transducer elements which measure the phase offsets of acoustic returns. The phase offset is used to calculate the angle (θ) from which the return was received. The angle, in combination with range based on two way travel time, is used to calculate the position of the seafloor and objects upon it relative to the instrument. This provides accurate bathymetric data co-located with SSS imagery which can be used to create either side-scan sonar (SSS) imagery, bathymetry, or imagery with associated depths[10]. Interferometric sonar systems are capable of providing improved efficiency over shallow water multi beam sonar systems. The interferometric sonar can be

10 http://ushydro.thsoa.org/hy05/08_4.pdf

considered as a multi-stave sidescan, collecting a wide swath of bathymetry and sonar amplitude data, with the angle of arrival of the seabed returns determined by phase comparisons between the receive staves.

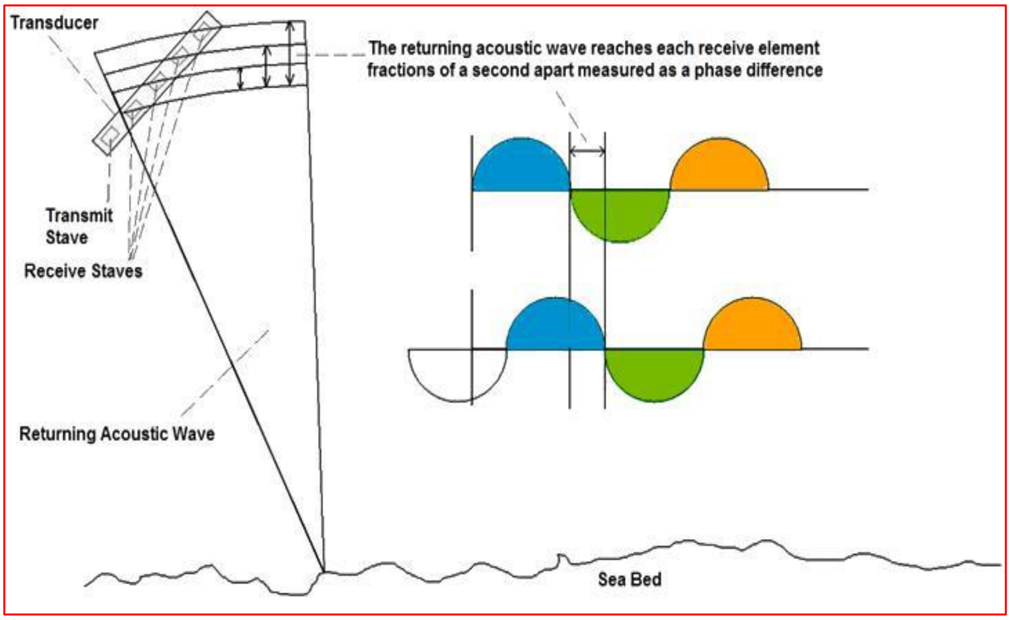

Fig 2.1 - Working Principle of Interferometry Sonar (*Source – Internet*)

2.6 **Synthetic Aperture Sonar (SAS)**. It is a form of SONAR in which sophisticated post-processing of sonar data are used in ways closely analogous to Synthetic Aperture Radar. Synthetic aperture sonars combine a number of acoustic pings to form an image with much higher along-track resolution than conventional sonars. The along-track resolution can approach half the length of one sonar element, though is downward limited by 1/4 wavelength. The principle of synthetic aperture sonar is to move the sonar while illuminating the same spot on the sea floor with several pings. When moving along a straight line, those pings that have the image position within the beamwidth constitutes the synthetic array. By coherent reorganization of the data from all the pings, a synthetic aperture image is produced with improved along-track resolution. In contrast to conventional side-scan sonar, SAS processing provides range-independent along-track resolution. At maximum range the resolution can be magnitudes better than that of side-scan sonars.[11]

2.6.1 The principle of Synthetic aperture sonar (SAS) is to combine successive pings coherently along a known track in order to increase the

11 Introduction to Synthetic Aperture Sonar by Roy Edgar Hansen

azimuth (along-track) resolution. A typical data collection geometry has the potential to produce high resolution images down to centimeter resolution up to hundreds of meters range. This makes SAS a suitable technique for imaging of the seafloor for applications such as search for small objects, imaging of wrecks, underwater archaeology and pipeline inspection.

2.6.2 In underwater applications, beamforming can be used to produce different types of products. For high frequency sonar imaging, this can be categorized into three different types:-

(a) **Sector Scan Sonar** produces a two-dimensional image for each pulse. These images are usually shown on a display pulse by pulse. Sector scanning sonar is often used as hull mounted sonars for forward looking imaging or wide swath imaging. In fisheries acoustics, some cylindrical arrays actually produce full 360 degrees view.

(b) **Side Scan Sonar** is a particular type of sonar that uses the platform motion to cover different parts of the seafloor. A side scan sonar produces one or a few beams around broadside, and an image of the seafloor is produced by moving the sonar and using repeated pulses. This is a very popular technology, it has fairly low hardware complexity and can therefore be more affordable.

(c) **Synthetic aperture sonar (SAS).** It uses multiple pulses to create a large synthetic array (or aperture). From this, an image of the seafloor is produced such that the information from multiple pulses goes into each pixel on the seafloor. It is, from a certain point of view, the combination of side scan sonar and sector scan sonar.

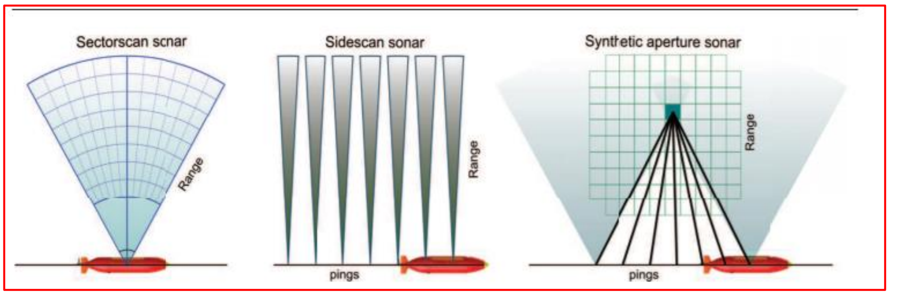

Fig 2.2 - Different SONAR Technologies (*Source – Internet*)

(d) **Design of a SAS**. SAS is different from traditional sonar in several ways namely:-

(i) **Resolution**. While traditional imaging sonar has constant angular resolution, and thereby range dependent along-track resolution, SAS produces range independent along-track resolution. This is done by increasing the length of the synthetic array as function of range. Hence, the along-track resolution for full length synthetic apertures is given by the element size alone, independent of range.

(ii) **Frequency Dependence**. Another intriguing fact is that SAS provides frequency independent along-track resolution. This is achieved by increasing the length of the synthetic aperture for decreasing frequency. The lower frequency requires a longer synthetic aperture than the higher frequency for a fixed resolution. The angular spread, however, becomes frequency dependent. For lower frequency SAS, larger angular spread is needed for a given along-track resolution. The best possible along-track resolution that can be achieved is $\delta x = \lambda/4$, for 180º field of view. The frequency independence gives a degree of freedom compared to traditional sonar. Seawater is a dissipative medium for acoustic waves through viscosity and chemical processes. Acoustic absorption in seawater is frequency dependent, such that lower frequencies reach longer than higher frequencies. For a given reception threshold (sensitivity), the maximum achievable range changes substantially. In traditional sonar, a typical design criterion is to choose the highest possible frequency for the desired range. Then design the transmitter and receiver arrays to obtain best possible azimuth resolution. In SAS, the along-track resolution is independent of frequency. This allows the center frequency to be chosen for other reasons than resolution.

(e) **Principal** The principle of SAS has been known in more than 40 years, but it is only the last few years SAS has become commercially available. The main reason for this is the specific challenges that has to be solved for successful SAS imagery. Some of these challenges are elaborated below:-

(i) **Navigation**. The sonar has to be positioned with accuracy better than a fraction of a wavelength along the synthetic aperture. This is the same requirement as for any other array sensor, but inherently more difficult to obtain since a synthetic antenna is formed by a moving platform. A sharp image depends on accurate positioning of the elements in the array. How much error is tolerated is dependent on the scale of the error and the required image quality. Navigation of underwater platforms is more difficult than navigation of airborne and terrestrial platforms because GPS is not available. This challenge is the most important, and the first that has to be overcome for successful SAS imagery.

(ii) **Topographic errors**. When running a vehicle on a non-straight track, a non-straight synthetic aperture is formed and the imaging geometry becomes dependent on the full three-dimensional geometry. This means that the position of the sonar has to be known and the topography (or bathymetry) of the scene to be imaged has to be known. Only then, successful SAS processing can be done. This is critical for robust SAS, and a significant problem since the topographic changes in rough terrain may impose severe non-linear tracks. There are two solutions to this challenge: either run on a straight line or obtain a map of the area before synthetic aperture processing. The former is impractical (or impossible) on small platforms such as autonomous underwater vehicles (AUVs) or towfish systems. The latter can be obtained by using an interferometric sonar to map the scene prior to SAS processing.

(iii) **Ocean environment**. SAS is near-field imaging. This implies that the sound velocity has to be accurately estimated for well-focused imaging. The sound velocity in the ocean varies with depth. There might also be local horizontal and temporal variations. This can cause variation in the sound velocity of up to 2% along the acoustic path. To overcome this, the sound velocity can be measured directly or calculated using a Conductivity, Temperature, Depth (CTD) sensor.

(iv) **Vehicle stability**. SAS systems are generally multi-element receiver systems. This affects synthetic aperture processing in several ways. For vehicles operated in a crabbing environment (where the heading is not aligned with the track), a baseline occurs between overlapping elements. Even if the track is perfectly linear, the synthetic aperture becomes non-linear and the image quality in SAS processing becomes dependent on the topography accuracy. Large crab-induced baselines is challenging for imaging.

(v) **Multipath environment**. When operating in shallow waters, multiple reflections (or multipath) via the sea surface might affect the performance of sonar. This can affect the SAS data threefold:-

- Can potentially lower the temporal coherence between pings
- Can reduce the spatial coherence in interferometry; and
- Can add unwanted signal to the SAS images, causing loss of shadow contrast and fidelity.

(f) The latter two problems applies to all sonars in shallow waters, not only SAS. How much the shallow water environment affects SAS is actually dependent of the seafloor conditions, the sound velocity profile and the sea surface roughness.

(g) **Properties of a SAS**. The goal of sonar imaging is to estimate the acoustic reflectivity in the best possible manner, given the sensor and geometry. Some common measures of system performance are:-

(i) Geometrical resolution or detail resolution
(ii) Radiometric resolution or contrast / value resolution
(iii) Dynamic range or resolvability of small targets in the presence of large targets
(iv) Sensitivity or detection ability of low level targets
(v) Temporal resolution or framerate

2.6.3 Synthetic aperture sonar (SAS) is an advanced signal processing technique to improve resolution in sonar imagery. The main application is detailed documentation of the seafloor, in areas such as search for small objects, underwater archaeology, detailed seabed mapping and documentation of underwater installations. Successful SAS is dependent on accurate knowledge about the sonar position, the ocean environment and the seabed topography. SAS is substantially more mature now than what it was a few years ago with the development of technology.

2.7 **Autonomous Underwater Vehicles**. Unmanned and autonomous systems are already occupying the sky, and developments in recent years have also seen them take to water bodies. A big step forward in marine robotics, these systems can assist with numerous applications in Hydrography.

2.8 An autonomous underwater vehicle, or AUV, is a self-propelled, unmanned, untethered underwater vehicle capable of carrying out simple activities with little or no human supervision. These are often used as survey platforms to map the seafloor or characterize physical, chemical, or biological properties of the water. A large variety of AUVs are in existence, ranging from vehicles weighing tens of kilograms, to vehicles weighing thousands of kilograms. Motivations for employing AUVs range from the ability to obtain superior data quality, for example, obtaining high-resolution maps of the deep seafloor, or to establish a pervasive ocean presence, for example, using many small AUVs to observe oceanographic fields. While the technology development and occasional scientific use of AUVs have occurred since the 1960s, routine use of these vehicles for science is a phenomenon of the last few years. Adoption of AUVs has led to increasing investment in this technology, and also the establishment of successful commercial suppliers and services. AUV technology continues to evolve rapidly and a wide range of new vehicles and new applications are under development. These vehicles carry sensors to navigate autonomously and map features of the ocean. Typical sensors include compasses, depth sensors, sidescan sonars, Inertial Navigation System, GPS, USBL sensors, Multibeam Echo Sounder, Doppler Velocity Log, Acoustic Doppler Current Profiling, Synthetic Aperture Sonars, high resolution video and still camera, magnetometers, thermistors, conductivity probes etc.

2.8.1 **Navigation**. Radio waves cannot penetrate water very far, so as soon as an AUV dives it loses its GPS signal. Therefore, a standard way for AUVs to navigate underwater is through dead reckoning. Navigation can however be improved by using an underwater acoustic positioning system. When operating within a net of sea floor deployed baseline transponders this is known as LBL navigation. When a surface reference such as a support ship is available, ultra-short baseline (USBL) or short-baseline (SBL) positioning is used to calculate where the sub-sea vehicle is relative to the known (GPS) position of the surface craft by means of acoustic range and bearing measurements. To improve estimation of its position, and reduce errors in dead reckoning (which grow over time), the AUV can also surface and take its own GPS fix. Between position fixes and for precise maneuvering, an Inertial Navigation System on board the AUV calculates through dead reckoning the AUV position, acceleration, and velocity. Estimates can be made using data from a Inertial Measurement Unit, and can be improved by adding a Doppler Velocity Log (DVL), which measures the rate of travel over the sea/lake floor. Typically, a pressure sensor measures the vertical position (vehicle depth), although depth and altitude can also be obtained from DVL measurements. These observations are filtered to determine a final navigation solution.

2.8.2 **Power**. Most AUVs in use today are powered by rechargeable batteries (lithium ion, lithium polymer, nickel metal hydride etc.), and are implemented with some form of Battery Management System. Some vehicles use primary batteries which provide perhaps twice the endurance—at a substantial extra cost per mission. A few of the larger vehicles are powered by aluminum based semi-fuel cells, but these require substantial maintenance, require expensive refills and produce waste product that must be handled safely. An emerging trend is to combine different battery and power systems with super capacitors.

2.8.3 **Applications**. AUVs can be deployed to areas which are in accessible. With the development of more advanced processing capabilities and high yield power supplies, AUVs are now being used for more and more tasks with roles and missions constantly evolving.

(i) **Commercial**. The oil and gas industry uses AUVs to make detailed maps of the seafloor before they start building subsea infrastructure; pipelines and sub sea completions can be installed in the most cost effective manner with minimum disruption to the environment. The AUV allows survey companies to conduct precise surveys of areas where traditional bathymetric surveys would be less effective or too costly. Also, post-lay pipe surveys are now possible, which includes pipeline inspection. The use of AUVs for pipeline inspection and inspection of underwater man-made structures is becoming more common.

(ii) **Research**. Scientists use AUVs to study lakes, the ocean, and the ocean floor. A variety of sensors can be affixed to AUVs to measure the concentration of various elements or compounds, the absorption or reflection of light, and the presence of microscopic life. Examples include conductivity-temperature-depth sensors (CTDs), fluorometers, and pH sensors. Additionally, AUVs can be configured as tow-vehicles to deliver customized sensor packages to specific locations.

(iii) **Close investigations**. Since the AUV can be deployed very close to the sea surface, it allows the user to gather data of a very high resolution. Autonomous underwater vehicles, for example AUV ABYSS, have been used to find wreckages of missing airplanes

(iv) **Military applications.** The AUVs are being deployed on the following taskings by the world Navies:-

- Intelligence, surveillance, and reconnaissance
- Mine countermeasures
- Inspection/identification
- Oceanography
- Communication/navigation network nodes
- Payload delivery
- Information operation

(v) **Hobby**. Many roboticists construct AUVs as a hobby. Several competitions exist which allow these homemade AUVs to compete against each other while accomplishing objectives

2.9 **Autonomous/Unmanned Surface Vehicles**. Unmanned surface vehicles are smart platforms that can help surveyors improve the safety and efficiency of hydrographic survey projects. Their lightweight designs and autonomous systems make them well suited to and widely used in hydrographic surveys of rivers, channels, shallow water, lakes and reservoir. Unmanned surface vehicles (USV) or autonomous surface vehicles (ASV) are vehicles that operate on the surface of the water (watercraft) without a crew. USVs are valuable in Hydrography, as they are more flexible. Powered USVs are popular for use in hydrographic survey. Using a small USV in parallel to traditional survey vessels as a 'force-multiplier' can double survey coverage and reduce time on-site. Military applications for USVs include powered seaborne targets and mine hunting. Operational USVs with offensive capability[12]. The USV can be fitted with the desired sensor suite comprising of DGPS, SBES/MBES and a Motion reference unit.

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12 https://www.ee.co.za

This can be deployed to areas which are difficult to be accessed by a vessel. Since they are light weight and have very shallow draft, they can also be deployed in areas a manned vessel cannot approach. The mission can be pre-planned and can be recovered easily on completion of a task. They can be easily transported both on land or by a mother vessel as they are small in size.

Fig 2.3 - ASV in operation (*Source – Internet*)

2.10 **Remotely Operated Vehicles**. A remotely operated underwater vehicle (ROV) is a tethered underwater mobile device. ROVs are unoccupied, highly manoeuvrable, and operated by a crew either aboard a vessel/floating platform or on proximate land. They are common in deep water industries such as offshore hydrocarbon extraction. They are linked to a host ship by a neutrally buoyant tether or, often when working in rough conditions or in deeper water, a load-carrying umbilical cable is used along with a Tether Management System (TMS). The TMS is either a garage-like device which contains the ROV during lowering through the splash zone or, on larger work-class ROVs, a separate assembly which sits on top of the ROV. The purpose of the TMS is to lengthen and shorten the tether so the effect of cable drag where there are underwater currents is minimized. The umbilical cable is an armoured cable that contains a group of electrical conductors and fiber optics that carry electric power, video, and data signals between the operator and the TMS. Where used, the TMS then relays the signals and power for the ROV down the tether cable. Once at the ROV, the electric power is distributed between the components of the ROV. However, in high-power applications, most of the electric power drives a high-power electric motor which drives a hydraulic pump. The pump is then used for propulsion and to power equipment such as torque tools and manipulator arms where electric motors would be too difficult to implement subsea. Most ROVs are equipped with at least a video camera and lights. Additional equipment is commonly added to expand the vehicle's capabilities. These may include sonars, magnetometers, a still camera, a manipulator or cutting arm, water samplers, and instruments that measure water clarity, water temperature, water density, sound velocity, light penetration, and temperature. Also optical-stero cameras have been mounted on ROVs in order to improve the pilots' perception of the underwater scenario. [13]

Fig 2.4 - Remotely Operated Vehicle in Operation (*Source – Internet*)

2.11 **Scanning Hydrographic Operation Airborne (SHOALS) LIDAR**. The SHOALS system uses state-of-the-art LIDAR (Light Detection and Ranging} technology to measure water depth. A laser transmitter/receiver mounted underneath the aircraft transmits a laser pulse. The laser energy travels to the air-water interface where a small portion of this energy reflects back to the aircraft receiver (surface return}. The remaining energy propagates through the water column and reflects off the sea bottom (bottom return}. The water depth is a direct function of the time differential between the surface and bottom returns. The strength of the bottom return is affected by both bottom type and water clarity. Typically, LIDAR bathymeters will measure to depths equal to approximately three to five times the Secchi depth, or visible depth.

[13] https://en.wikipedia.org/wiki/Remotely_operated_underwater_vehicle

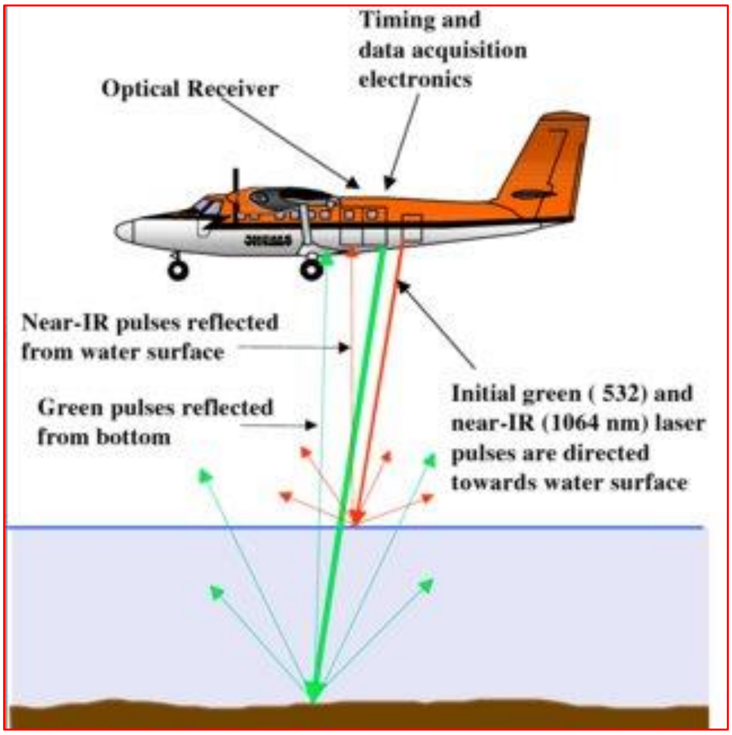

Fig 2.5 - Principle of SHOALS (*Source – Internet*)

2.11.1 The basic principle of the Advanced Light Helicopter (ALH) system is that the airborne lidar sends two laser wavelengths down to the water surface, as shown in above figure viz Green Pulse (532 nm) and IR pulse (1062 nm). Green pulse has a greater penetration power compared to the IR pulse. The IR pulse is reflected from the surface while the Green pulse travels through the water column and gets reflected from the bottom. The water depth may be calculated from the time difference of laser returns reflected from the sea surface and seabed.

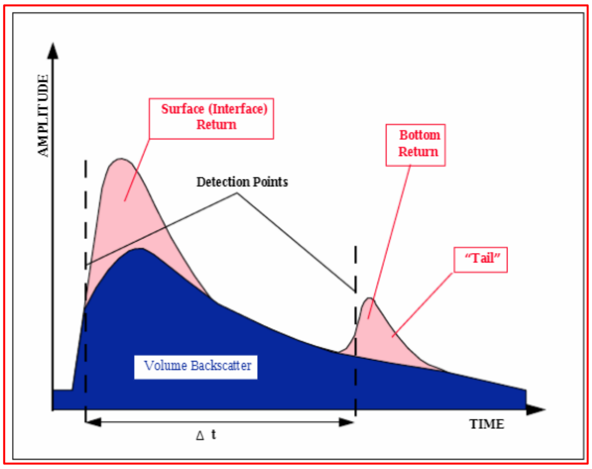

Fig 2.6 - Amplitude vs Time Graph Series for LIDAR (*Source – Internet*)

2.11.2 The laser beams are either swept in an arc or in a rectilinear scan across the direction of travel with a swath width typically half of the altitude. The surface sounding density can be varied from as small as 2 x 2 meters up to 5 x 5 m spacing and higher. Since the spot size on the surface is typically greater than 2 m this implies the possibility of complete coverage of the surface of the water at high sounding densities. The basic limitation of depth capability is the clarity of the water. Hence the maximum depth measurable by a system is heavily dependent on water turbidity and can vary considerably from just a few meters in very turbid water to several tens of meters in clear water.

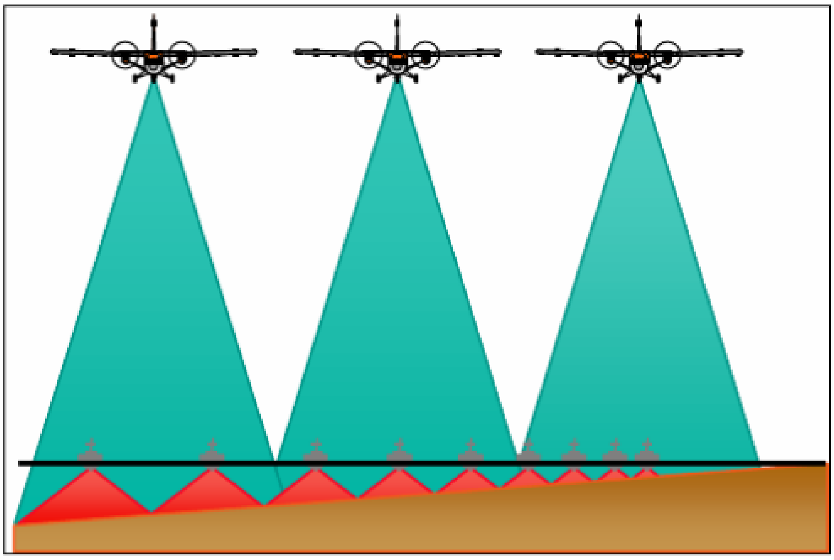

Fig 2.7 - LIDAR Swath vs MBES Coverage (*Source – Internet*)

2.11.3 This technique has significant savings over conventional acoustic methods. Therefore, ALH is rapidly becoming the tool of choice in clear, shallow waters since it will usually achieve coverage rates several orders higher than current launch methods at less cost per square mile. A cost-effective manner; operating within relatively clear, shallow water regions, which are among the most costly, hazardous, and time-consuming areas for ship and boat operations. In summary, survey launches suffer from their dependence on a 'Mother' ship or local operating base, slow coverage rates and vulnerability to grounding damage; ALH has the potential to overcome all these disadvantages. The potential benefits of ALH are considerable and will continue to open up new opportunities in fields as diverse as regional sediment management and warfighting support. Development trends of ALH are already towards, smaller, cheaper and more automated systems that have the potential to be pod-mounted or even flown in Unmanned Airborne Vehicles (UAV). As a consequence, future systems are likely to be cheaper to run and offer even greater degrees of flexibility.

2.12 **Satellite Derived Bathymetry**. Satellite-Derived Bathymetry (SDB) is the most recently developed method of surveying shallow waters. In contrast to other survey methods, it requires no mobilisation of persons or equipment, provides rapid access to bathymetric data and saves costs. Satellite-Derived Bathymetry makes operations in shallow water more effective and reduces project risks. Satellite Derived Bathymetry refers to depths processed from optical satellite imagery. SDB is based on the expectation that deeper water appears darker than shallower water. This simple analogy is complicated however as a shallow black rock can appear darker than surrounding deeper sandy seabed. Complex mathematical analysis of the imagery attempts to distinguish these differences and remove the many other sources of 'noise' in a satellite image and produce a best estimate for the average depth in each pixel. Satellite imagery is available at many different resolutions. Only imagery of a resolution higher than 30 m is suitable (and appropriate) for charting, as SDB results in an average depth per pixel. Even when using 30 m resolution imagery the results should be used with caution as many shoal depths may not have been detected. SDB processing requires multispectral imagery, which in the commercial sector is currently limited to a maximum resolution of 1.24 m (World View-3). Higher resolution imagery is usually black and white and not able to provide SDB. Unlike "active" depth measurement techniques such as echo sounders or Light Detection and Ranging (Lidar), where controlled signals are transmitted and received, SDB is a "passive" technology and is simply measuring the reflected sunlight intensity. Because of this, SDB results are affected by many more uncontrollable environmental factors. SDB is limited to shallow clear waters where the seabed can be seen in the imagery. Its results can be adjusted and improved by providing "ground truth" data using more conventional survey techniques (e.g. echo sounder). Industry claims of accuracies of 10% of depth were not borne out by early experiences of SDB within the United Kingdom Hydrographic Office (UKHO).[14]

[14] Paper for Consideration by CSPCWG Satellite Derived Bathymetry by UKHO

2.12.1 In general, SDB data can offer:-

(i) **Good coverage**. Within depth and image limitations; not as good as Multi-beam echo sounder (MBES), some objects may be missed, but better than single-beam echo sounders (SBES) and leadline.

(ii) Better object detection, but not as good as SBES used with side scan sonar or a MBES.

(iii) **Good positional accuracy**. Similar to MBES and SBES. Better than historic lead line.

(iv) Lesser depth accuracy than MBES, SBES and leadline.

(v) Significantly save costs

(vi) Reduce risks for on-site activities

(vii) Survey inaccessible and remote areas.

2.12.2 A trial was undertaken by UKHO to make an informed decision regarding the suitability of SDB as a data source for navigational products and also gain an understanding regarding optimal parameters of data acquisition.

(a) **Methodology**. To acquire the best quality MBES and SDB data within a given area and compare them, using the MBES data as the benchmark. UKHO conducted a high resolution, high quality, MBES survey along the south coast of Antigua in September 2013. This area was chosen for the trial as it offered clear water with a range of depths and a mix of simple sand and complex coral seabed. The MBES data typically met the vertical and horizontal uncertainty requirements for S44 “special order”, the object detection requirements for S44 “Order 1a” and CATZOC A1. Satellite imagery was tasked with optimal parameters and acquisition that took place during the MBES survey in order to remove any doubt that the seabed could have changed. Imagery was acquired from the Worldview-2 satellite, one of the most advanced civilian imagery satellites available at the time of the trial, with a pixel resolution of 2 m. The imagery was processed using several different SDB processing methods, both in house and through commercial companies, in order to compare them and understand repeatability of this technology. Data was corrected to chart datum using observed tides.

(b) **<u>Results</u>**. Results were looked at in terms of both overall accuracy (compared to MBES dataset) and SDB's ability to define critical soundings. These factors were then used to assess a suitable CATZOC classification for SDB data. All the conclusions are based on the most accurate SDB dataset from the trial (which was provided by ground truthed data from one of the external companies). A series of profiles were taken showing the MBES data against different versions of the SDB data. These are shown below and indicate that SDB is able to detect the general shape of the seabed.

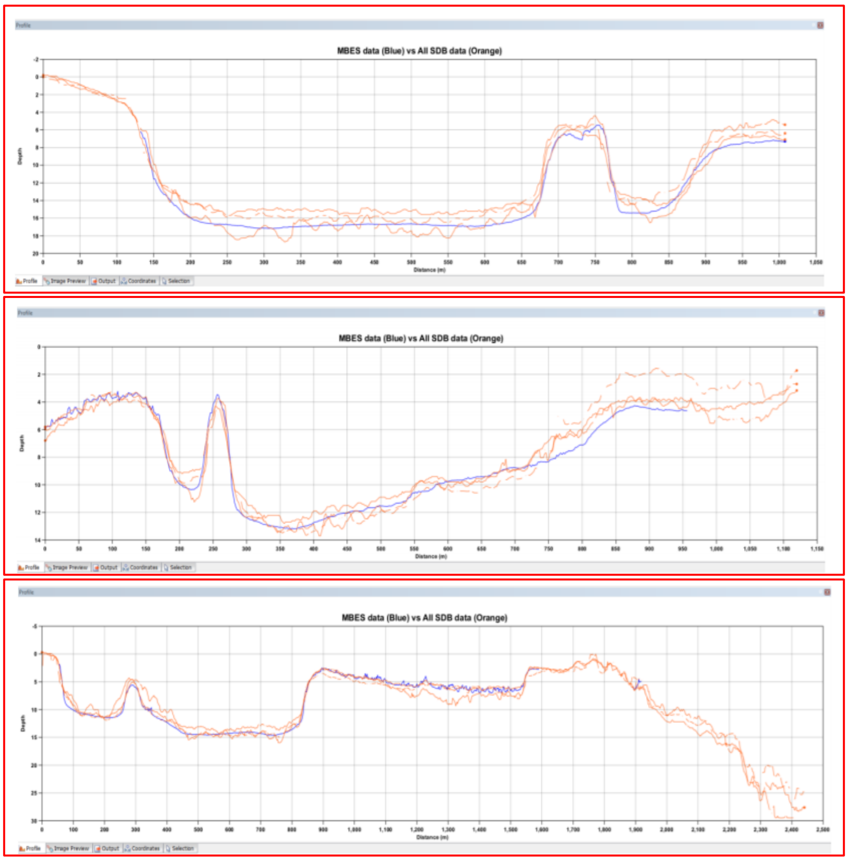

Fig 2.8 - Blue line is MBES data and Orange line is SDB

(c) Like a conventional hydrographic survey, different processing methods make a clear difference to the SDB data. Validation of both source imagery and processing is required to ensure optimal results are achieved. Using ground truth data improved the SDB results. The uncertainty of the SDB data increased with depth. In the case of this trial, only SDB data shallower than 15 m was considered reliable. It is expected that this 'cut-off' depth would be different for data acquired in different areas and from different imagery. The actual cut-off depth can only be determined reliably using ground truth data. The SDB trial data does not meet IHO S-44 survey standards. Though more than 97% of the "Commercial Company 1" data could be categorised as CATZOC C, the data that fails CATZOC C requirements is spread throughout the data set and would be difficult to delineate. SDB has detected the majority of features though, which is in the spirit of CATZOC C, and unlike traditional CATZOC C data, such as leadline, does not consist of large areas where no data exists at all. Until further work has been done on quality control parameters and error budgets, ground truthing would be required to prove that CATZOC C had been attained. The trial SDB data was accurate to approximately ±2-3 m when compared to the MBES data, though much of the data was better than this. Though SDB technology is not able to match echo sounders for accuracy it can give an indication of the shape of the seabed. It is likely that some features will be missed and though the technology can obtain depths as deep as the water clarity will allow, the reliability of these depths greatly decreases as the depth increases. This trial was conducted in waters that are favourable for the use of SDB and using high resolution imagery. Further work is needed to assess the performance of SDB in less favourable conditions and with lower resolution imagery. In this case, the ground truthed SDB data was capable of making the chart safer. Good SDB data can be of value when navigating but the mariner needs to understand the uncertainty of the data and how it differs from surrounding data in order to use it appropriately.

2.13 **<u>Crowd Sourced Bathymetry</u>**. Crowd sourcing can be understood as the exploitation of a well dispersed but underutilised resource and make collective use of the data that is being gathered. <u>Crowd Sourced Bathymetry (CSB), as defined by the IHO website is a collection of depth measurements from vessels, using standard navigation instruments, while engaged in routine maritime operations</u>. Crowd Sourced Bathymetry (CSB) data may be collected by any type of vessel, using a variety of sonar systems and for myriad reasons. Enlisting the resources of merchant ships, recreational boaters, pilot boats, tug boats, cruise ships, as well as fully equipped research ships in the "opportunistic" mode, this acquisition of bathymetric data may potentially open data streams of current observations to navigators, cartographers, scientists, engineers, and coastal zone planners. The strengths and benefits of CSB data are the temporal frequency in repetitive and constant observations in heavily trafficked areas, access to an unlimited workforce and availability of critical nautical data for the maritime community within a short timeframe, and engagement of the wider user community that will readily contribute to the mapping of our coastal zone. [15]

2.13.1 CSB represents autonomously collected time, bathymetric and position data from vessels that operate without regard to bathymetric survey objectives to characterize the representation of seafloor structure. Crowdsourcing is a distributed problem-solving and production process that involves outsourcing tasks to a network of people (referred to as the crowd). This process can occur both online and offline. The difference between crowdsourcing and ordinary outsourcing is that a task or problem is outsourced to an undefined public rather than a specific other body.

2.13.2 Hydrographic surveys conducted prior to the emergence of global positioning system (GPS) technology relied on shore-based positioning using sextant resections and electronic ranging from geodetically located stations. Pre-GPS hydrographic surveys achieving a Total Horizontal Uncertainty (THU) of ±20 m were rare. Today, even the cheapest GPS system available to the public provides a vast improvement in positioning accuracy and reliability compared

[15] http://ushydro.thsoa.org/hy13/pdf/0326A_02_05.pdf

to the pre-GPS positioned hydrographic data. A large percentage of depths depicted on charts is sourced by data collected by antiquated lead line soundings and wire drags many decades ago. Surveying a small area systematically is expensive financially and consumes a lot of time and resources. As the budgetary resources continue to decline, Hydrographers are beginning to take crowd sourced data seriously.

2.13.3 Most of the vessels today which are navigating carry with them a satellite positioning set and an Echo Sounder. The only additional instrument which is required is a small processor capable of logging data. Most of the ECDIS are logging data today at the frequency defined by the user. This data set may also be utilised to extract the relevant Hydrographic information.

2.13.4 The Hydrographic data gathered using Crowd Sourcing techniques may conform to order 1(b) or Order 2 as Order 1 (a) and special order require 100 % sea floor coverage. CSB when a great enough density of data is achieved could achieve class A2 however as CSB is not a controlled systematic survey but data collected on an opportune bases its CATZOC class is C.

2.13.5 As a result of Decision 8 of the Extraordinary International Hydrographic Conference 5, the IHO Inter-Regional Coordinating Committee established a Crowd Sourced Bathymetry Working Group (CSBWG) at its 7th meeting in Mexico City. The CSBWG will examine how best to incorporate, manage and use bathymetric data acquired by other than conventional means and develop principles and guidelines to enable the appropriate collection and use of crowd sourced bathymetry for the benefit of all stakeholders interested in knowing the shape and nature of the seafloor and its depths. The CSBWG will draft an IHO publication (B-12) on policy for trusted crowd sourced bathymetry including guidelines on the collection and assessment of CSB data, not only for potential use for charting purposes but also for its wider use in non-navigational applications. The publication will take into account the work to enhance the IHO Data Centre for Digital Bathymetry (DCDB) as a data discovery and upload/download portal for Crowd sourced Bathymetry and lessons learned and specifications created during the IHO CSB pilot projects. [16]

2.14 **<u>Other emerging Trends</u>**. Some other trends that are emerging at the global scenario but are at very nascent stage are discussed in brief in succeeding paragraphs[17]:-

2.14.1 **<u>Time Lag to Adoption</u>**. One lesson is that whilst computers and computer processing have developed and continue to do so there is a time-lag between the next development and its full use and adoption. This is in part due to the cost of development and production as well as the availability to the market but also the perceived benefits (or lack of it) between existing computing capabilities and technologies.

2.14.2 **<u>GPS</u>**. A second aspect, when considering GPS, is that the relatively high cost of establishing a radio positioning system (often tens of thousands of dollars) for the very few hydrographic survey users was massively reduced, when GPS was proven to perform reliably, to a few hundred dollars. The effect of creating something with mass appeal enabled a very high engineering and development cost to be reduced for the user. Again a time-lag occurred as initial coverage, availability and performance issues were dealt with.

2.14.3 **<u>Mass Appeal and Availability</u>**. A third outcome is that the mass appeal and availability of emerging technologies, especially computers and GPS, have generated a great number of new and innovative uses and applications. An example could be the development of digital cameras replacing film-based cameras and of course smartphones that offer a location and include a camera. It’s perhaps unlikely that many of our hydrographic and offshore surveying developing technologies will see such dramatic change and innovation, but their adoption may be more effective and transformational with

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[16] https://www.iho.int/srv1/index.php?option=com_content&view=article&id=635&Itemid=988&lang=en

[17] https://www.hydro-international.com/content/article/trends-in-hydrography-2

integration into and together with other technologies. A further lesson to appreciate is that many technologies bring with them some form of unintended consequences. Not all are significant but some are. Few would have thought of the impact modern day Dynamic Positioning (DP) vessel systems would have on reducing the need for the survey system installations or the security implications of, for example, pirates' use of AIS (the Automatic Identification System).

2.14.4 **Data Volume Growth**. Data, the final frontier for many, which has been with us in some form forever, continues to grow in volume and complexity and consequently offers an opportunity and a challenge. Yes MBES, LIDAR, remote sensing platforms and scanning systems create and generate large volumes of data. In fact, the vast volume of data they are generating has caused the traditional silos of the data owners to become too large and cumbersome when filled and data is to be made more and more available for other potential users. In reality, consuming these datasets is constrained due to access being limited, varied formats, limited metadata to explain what is present and simply knowledge of the data's existence and availability. It is anticipated that development efforts will be made to enable these large data volumes to be made more accessible, more easily consumed and to actually provide some additional value and benefits for the wider user community.

2.14.5 **Backscatter Data**. An important recent trend has seen surveys collect not just seafloor depth and associated backscatter data but now more and more operations are able to adjust their data collection to include the water column data. This has a potentially large new consumer base of users interested in the water and oceanographic components.

2.14.6 **Data Sharing**. Of course, the generation of large datasets is all well and good, but if we are not able to share and distribute the data for the broader community to use then some of the benefits will be lost. Responsible agencies and institutions will endeavour to share their data and the EU has encouraged this through such programmes as the INSPIRE initiative. However, wouldn't it be great if we had contractual terms that removed the privacy and exclusive use of the data after a reasonable period of time so that we could develop a more recognised supply of information. So the continual trend of new and ever more data-rich systems will have an impact on some of the traditional projects that we would normally undertake. However, let's not pretend that SDB or a swarm of AUVs will be totally effective and efficient in mapping our seas and oceans at a useful resolution and accuracy (A totally new topic for later!). Rather, we still need to develop a seriously efficient, cost-effective mapping technology to cover our seafloors and water column. Currently, AUVs are too slow, of limited power and thus range and duration, but also they collect but don't easily distribute their large volumes of data.

2.14.7 **Resolution**. Current global seafloor maps have inaccuracies in their depths of over 1km and much more often of hundreds of metres. Better coverage can be obtained, but SDB is of a relatively poor resolution relying too much on sparse depth measurements to be accurate. AUVs that do offer the ultimate in data resolution are limited by their range and duration. What is really needed is a truly accurate high-resolution surface-based, or near surface-based, system that can operate very efficiently and transfer its collected data as it surveys. There are several initiatives to increase our knowledge and understanding of the oceans. A well-established one is that of GEBCO (the General Bathymetric Chart of the Oceans) being directed under the auspices of the International Hydrographic Organization (IHO) and the Inter-governmental Oceanographic Commission of UNSECO. It has recently announced its aim of mapping the world's oceans by 2030. A significant challenge that would benefit from improvements in acoustic, autonomous vehicle and data processing technologies. Another interesting programme is the Atlantic Ocean Research Initiative that includes, through its Coordination and Support Action, efforts to map areas of the unexplored north Atlantic as part of the Canada/USA/Europe Galway Statement. What these initiatives represent is a clear will, both politically and economically, to further map and understand our seas and oceans. However, for the benefits to be truly realised technological advancements will be required, e.g. in terms of data resolution (it should be in the order of sub 10 metres on the seafloor or at the 0.075 to 0.1 degree beamwidth).

2.15 **Developing Survey Professionals**. A further trend to be mentioned is that of demographics. In the past there were offshore surveyors and engineers. Some navy personnel were recorders but that seemed a luxury only available on permanently fitted vessels. Then came specialist engineers for the acoustics, ROVs, followed later by data processors and report coordinators. The range of equipment appeared to increase too. It was an exciting environment with varied and interesting projects that often involved doing new things. The industry is still exciting, but can we still attract Millennials into our profession and do they have the necessary skill base or is their education leaving our industry behind as they gain alternative new and exciting career opportunities? The development of new technologies can continue to be an attraction to young professionals so it's important that we support and sustain appropriate training and educational institutions. This could help in determining what skill sets and competencies are of the greatest benefit and those that are perhaps no longer as useful.

2.16 **Attracting Talent**. Whatever technology we develop, adapt and adopt we must strive to inspire, encourage and attract the future talent to ensure that hydrographic surveying remains a truly exciting and rewarding activity. This is a trend that will continue and may become even more vital in our specialist sector to secure a future with skilled people enjoying a continuously evolving career. Whilst the exciting technology will evolve and hydrography and offshore surveying adapts, we will, as a profession, increasingly make a significant impact on the world. It would be nice if the rest of the world became aware of just how great it is going to be.

2.17 **Conclusion**. The ocean is the lifeblood of Earth, covering more than 70 percent of the planet's surface, driving weather, regulating temperature, and ultimately supporting all living organisms. Throughout history, the ocean has been a vital source of sustenance, transport, commerce, growth, and inspiration. Yet for all of our reliance on the ocean, more than eighty percent of this vast, underwater realm remains unmapped, unobserved, and unexplored. Given the high degree of difficulty and cost in exploring our ocean using underwater vehicles, researchers have long relied on technologies such as sonar to generate maps of the seafloor. Currently, less than ten percent of the global ocean is mapped using modern sonar technology.[18] Therefore there

[18] https://oceanservice.noaa.gov/facts/exploration.html

is an urgent need to improve the situation and try mapping the ocean sea floor at the earliest. This can be only achieved if modern technology is effectively used and all the Hydrographic states pledge to participate whole heartedly as a single community to map the oceans.

CHAPTER 3

IMPORTANCE AND ECONOMIC IMPACT OF HYDROGRAPHY – A TOOL FOR DEVELOPMENT

There can be no exploitation of resources at sea without exploration and there can be no exploration at sea without hydrography

- *Anonymous*

3.1 The oceans cover 70% of the earth's surface. With half of the world's population living within the coastal zone, oceans annually contribute $ 1.5 trillion to the world's economy[19]. Maritime commerce is a basic enabler for the economies of most nations as more than 80% of international trade is carried by sea.[20] Almost every human activity that takes place in, on or under the sea requires some knowledge of the hydrography of the area-in other words, knowledge of the shape and nature of the seafloor, its characteristics and hazards. Therefore, in addition to supporting safe and efficient maritime trade, hydrography underpins almost every other activity such as Coastal Zone Management, exploration and exploitation of marine resources, environmental protection, marine science, tourism, maritime boundary delimitation and maritime defence.[21]

3.2 It is rather unfortunate that we being a maritime nation the importance of maritime services take a back stage. This is inspite of our very first Prime Minister Pt Jawaharlal Nehru famously quoting "***Jalmev* Yasya, *Balmev Tasya*** (The one who controls the sea is all powerful) and that too in early 50s. This somehow never caught the passion of the people who mattered. In order to address the issue holistically and do a justice to this research, it is imperative that we first answer the following questions

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[19] The Ocean Economy in 2030-ISBN 978-92-64-251724 © OECD 2016

[20] UNCTAD/RMT/2016 United Nations Publication-Review of Maritime Transport-2016

[21] IHO Publication M-2, The Need for National Hydrographic Services-Ver 3.06-Dec 2016

related to this very important maritime service that arises in the minds of uninitiated and those people who are dealing with this subject:-

(a) Why a National Hydrographic Service?
(b) What is the importance of Hydrographic Information and its Influence?
(c) What are the economic benefits of Hydrography and Ocean Mapping?
(d) What is the Economic Impact of Hydrographic Surveys?

It has been the endeavour to discuss and address all the above questions and issues related with it in this chapter.

3.3 **Why a National Hydrographic Service[22]?** Assessing the worldwide hydrographic surveying and nautical charting status we can conclude that despite over 90% of international trade being conducted by sea, reliable cartographic coverage has not yet been reached everywhere and still several areas within Central America and the Caribbean Sea, the South West Pacific, Africa and some regions in Asia represent a risk for shipping operations. Despite the understanding of the close relation and influence that exists between the ocean and climate change, and being aware of the severe effects of different natural hazards, the origin of which seems to be strongly related to global change, as a society we do not give priority to learning and better understanding the characteristics of oceans and seas. Moreover, despite the evident deterioration of the marine environment due to the increase of population living in the coastal region and the increase of activities that discharge different elements to the sea, we, as a society are not keen to consider, with sufficient priority, the need to have reliable hydrographic information to adopt the most efficient and effective preventive and remedial measures to ensure clean seas. Since the very early days of man's presence the sea has been considered as a natural avenue that allows interconnectivity between different human groups, mainly to exchange their goods. Therefore, hydrography and the representation of its results in a nautical chart have always been part of life and have contributed to mankind's development as well. Due to its importance, the sea has also been the scene of disputes of its control. We can say that hydrography traditionally has contributed to both, commercial and naval operations. Nowadays and without losing its original main

[22] https://www.fig.net/resources/publications/figpub/pub57/pub57_article08.pdf

application, hydrography is called to contribute to many other activities including playing a key role in maritime delimitations; exploitation of marine living and non-living resources; tourism and sports; and others, all needing to be properly regulated, managed and controlled, aiming at sustainability and protection of the marine environment. It is evident that somebody needs to have the responsibility, at a national level, of conducting hydrographic surveys and producing nautical charts, also of building and keeping hydrographic databases for the preparation of special products required by those in charge of regulating, managing, controlling and operating in and on the oceans and seas. This fact that is very well understood, - especially by countries with a maritime tradition, conscious on the vital role the sea plays for their economies -, but not so by many other countries that do not give it priority, even to the development of a basic hydrographic capability. Probably the relationship between hydrography and safety to navigation is more evident than the existing relationship with other activities, due to international regulations.

In fact, the SOLAS (Safety of Life At Sea) Convention – under the aegis of the International Maritime Organization (IMO) –, provides clear regulations with regard to safety to navigation and all related elements. Particularly Regulation 9 “Hydrographic Services”, identifies what a contracting Government shall undertake. In brief, as detailed in this regulation they should arrange for the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date, of all nautical information necessary for safe navigation. As can be appreciated, the main purpose is to guarantee, as much as possible, safe navigation, taking into account the recommendations and resolutions of the International Hydrographic Organization (IHO). Through the coordination between hydrographic offices, the IHO aims at ensuring that hydrographic and nautical information is made available on a worldwide scale as timely, reliably, and unambiguously as possible. In this case and as indicated earlier, the contribution of hydrography is evident, but it is
not so evident to the common public, that the availability of this data and information has also a vital role to support in the development of other activities of national, social and economic importance.

3.3.1 **Government and Private Sector Hydrographic information demand.** Hydrographic information is a national asset required by both, governments and private sectors. We cannot conceive any activity conducted in the sea or the development of any coastal or offshore project without hydrographic information. It is a government responsibility to administer, regulate, and control the use of the inland waters, interior waters, territorial sea, exclusive economic zone and continental shelf. How can government officials achieve this without knowing the characteristics of these environments? How can the private sector promote initiatives in these areas in the absence of Hydrographic information? Clearly the lack of hydro-cartographic information constitutes a strong limitation to achieve progress. We will not, in this paper, concentrate on the importance of hydrography with regard to safe navigation, shipping and related activities. As was indicated, this sector easily understands the contribution that hydrography makes to its development. On the contrary, we will concentrate on some other activities, some of them normally under government's responsibility and others more in connection with the interests of the private sector.

(a) **Governments' responsibility.**

(i) **Maritime delimitation**. As it is on land, each country needs also to establish, agree and set its international borders and boundaries. In the case of the delimitation with other countries, the limit must be drawn on the commonly accepted nautical chart and that chart must be the product of a hydrographic survey complying with international agreed standards. Probably the hydrographic survey will be a joint operation but what if one of the countries involved does not have any hydrographic capability? When establishing the limits of the territorial sea, contiguous zone, economic exclusive zone or the extension of the continental shelf, -if it applies -, the maritime state must base such delimitations on standard procedures where depths, distances, characteristics of the sediments, cartographic projections and representations must be considered. Finally lines representing such limits must be represented on nautical charts to make users aware. The mariner, the fisherman, the security forces and others, must be aware whose area and jurisdiction they are in, as for each area, different regulatory measures frequently apply. How are such measures and cartographic presentations made if a country does not have a national hydrographic capability? Further, this capability if existing must be a tool of diplomacy for the ministry of Foreign Affairs and its structure?

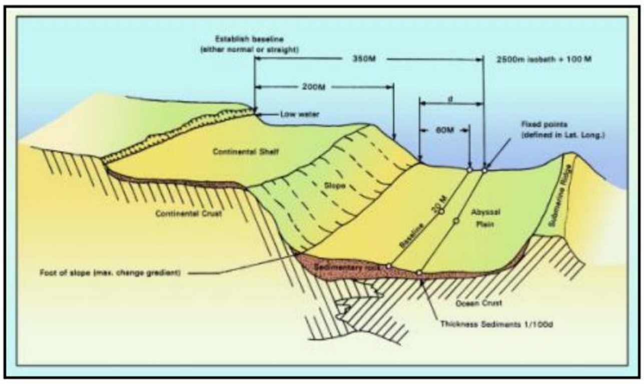

Fig 3.1 – Different Maritime Zones/ Limits (Source – Internet)

(ii) **Natural hazard preparedness**. Coastal zone management is a subject on its own due to its complexity and multiple related and dependent factors. One of the aspects that call for special attention is the effect of natural hazards such as tsunamis and storm surges. Being both of a very different origin, the point is that the coast is impacted by the rise of the water level and waves, respectively that have caused great lost of lives and damage to coastal communities with tremendous economic effect. Probably it is nonsense to aim at stopping nature delivering its energy, the risk always exists, but we can adopt measures to reduce the effects by an appropriate policy of preparedness. The direction of the energy that approaches from the sea towards the shoreline is driven by the bathymetric characteristics of the place. Therefore if we know the bathymetry, we can run models to determine the expected run-up under certain conditions. The result will be the zonification of areas of greater or lesser risk. This represents, especially for coastal communities, important information required to support the decision on where a settlement should or should not be established. In the absence of a national hydrographic capacity, who will provide these vital information to the National Emergency Agency for preparedness and what will be the response to such emergencies?

Fig 3.2 – Photo Depicting aftermath of Tsunami (2004)
(Source – Internet)

(iii) **Oil spills and Contamination**. If we are part of a conscious society we must take care of the environment, and that also includes the sea. There have been accidents and spills and nothing indicates that these will not happen again. Severe maritime accidents with oil spills that have required the action of concerted brigades to combat it can still make demands on the time, personnel and funds available to coastal areas. It must be an aim to reduce as much as possible the impact of such events on the marine environment, mainly close to the coast. There are quite a few examples of accidents, the effects of which have been assessed, have produced varying conclusions and ended with costs impossible to determine due their long lasting effect. It is not the cost of pumping or sweeping the beaches, is the cost of the consequential losses to the habitat, flora and fauna as well as local trade and commerce that are not recovered. To help in managing this type of disaster, bathymetry, currents, tides, winds, as well as other parameters are required. One important aspect that has been recognized is that without suitable data and a nautical chart in the area of the disaster; operations will be surely more difficult. Who will provide these hydrographic intelligence to the ministry of Environment?

Fig 3.3 – Photo depicting Oil spill in a Harbour (Source – Internet)

(b) **Private Sector interest**.

(i) **Fish Farming**. It is true that fish and seafood farming is an activity that cannot take place elsewhere, it has to be regulated and the area requires very special conditions from an environmental point of view, including bathymetry. How can the private sector go ahead with fish farming project? Certainly they need to comply with the regulations set by the authorities. How will authorities establish such policies if no environmental information and its variability are available? We agree that bathymetry is just one parameter, but that information and its representation on a chart is required, as knowledge of it can have a significant effect on establishing suitable sites that in turn may impact the routes used for surface navigation. Above statement clearly points towards the fact that the ministry of Fisheries will have to be dependent on hydrographic data to deal with this matter/

Fig 3.4 – Photo of a Fishing Farm (Source – Internet)

(ii) **Tourism**. Tourism is a very wide title and for this paper we will concentrate on just a little segment: the marinas for small vessels. Marinas provide shelter conditions to leisure yachts and boats, and constitute a focus of development due to the many activities that are associated. The provision of services and logistic support such as re-fuelling, restaurants, maintenance, shops; just to mention a few, offer the opportunity of different jobs. Therefore in the selection of the place where to build a marina, several factors are to be taken into consideration; one of which is the hydrographic condition. The infrastructure to be developed has, as the main objective, to provide the best and safer conditions to yachts and boats. The engineering studies to be conducted before any decision is adopted must include hydrographic surveys and charts of the area. Later, when in operation, the variation of the hydrographic conditions shall be monitored in order to keep the conditions safe for use of the marina. In case of the absence of any national hydrographic organization lots of questions will emerge and will have to be answered. Some of these questions are:-

- Who would like to take the risk of not considering hydrography in the development of a marina?
- Will the necessary hydrographic studies conducted be used for the preparation of an official nautical chart of the area?
- Will the private sector produce such a nautical chart and assume the responsibility for its quality?

- Will the ministry of Tourism require a hydrographic unit to validate whatever hydrographic information is produced by the private sector?

Fig 3.5 – Photo of a Tourist Yatch Harbour in Mediterranean Sea (Source – Internet)

(iii) **Cable laying**. Normally it is under a contract that the private sector works in cable laying. This engineering operation requires a very detailed representation of the seafloor; therefore special hydrographic surveys are conducted in order to decide on the best lay route of the cable. But that is not all. Due to the importance of the work, the position of the cable must be shown on the nautical chart to avoid any disruption caused by ships anchoring in the nearby or fishing vessels conducting deep trawling. In this case the private sector needs hydrographic information before the laying and afterwards, with the assurance that the mariner will be aware of the existence of the cable as it will be indicated in the nautical chart, probably with some explanatory/regulatory notes. If the preliminary survey is conducted by the private sector, that information can be used in the preparation of the official nautical chart. On the contrary, if hydrographic information already exists due to different reasons, it would be economic and efficient to make that information available to the private sector, especially if it is of national interest. In the above case, a very relevant question arises that who keeps the records of previous hydrographic surveys? And is that information a national asset?

3.3.2 **<u>Requirement of National Hydrographic Service</u>**. The Hydrographic Service is a national service of strategic importance capable of supporting the development of the highest maritime national objectives. It does not mean that in countries lacking a national hydrographic capability, no hydrographic activity takes place. In those countries the government hires some work and the private sector executes some works too. The problem is that without a National Hydrographic Service, there is no standard quality control and quality assurance on the information generated through these individual efforts. Moreover, the data and formation is not maintained and kept conveniently archived for future national uses. A maritime nation, with its strong dependency on the sea, cannot be exposed to not being capable of deciding and controlling any project at sea. It is true that conducting hydrographic surveys and producing nautical charts are activities that can be contracted, but it is a must to have the capability to understand and establish technical specifications and standards that must be followed; regulate the hydrographic activities conducted in national waters and control the accomplishment of that regulations. All this can only be managed by a centralized agency, the National Hydrographic Service, the characteristics of which shall be decided by the related stakeholders. Its mission and functions shall be considered a national objective and its administration shall receive the advised of a national hydrographic committee or similar coordination structure, integrated by all the stakeholders.

3.3.3 **<u>Economic Benefits</u>**. It is difficult to assess the economic benefit associated to the existence of a National Hydrographic Service, but if established according to the real needs of a country; its cost (running as well as the capital) shall not be considered expenditure, but an investment. Any attempt to use figures does not make any sense as figures are irrelevant due to the different cost of life and its representation in different parts of the world. Lets examine and analyze hydrography related activities as discussed above and the questions that arises thereon, of a country, which does not have its own dedicated national Hydrographic service:

(a) **Maritime Delimitation**. What will be the value of establishing national borders? How much resources will be spent in court cases due to the lack of maritime delimitation of the country? What is the value of the resources that country is not able to exploit due to non-availability of a clear maritime delimitation?

(b) **Natural Hazard Preparedness**. What will be the cost to re-establish a flooded village settled erroneously in a high risk coastal zone of the country? What is the cost of live of those in this risk zone?

(c) **Oil spills**. What has been the cost of cleaning beaches impacted by oil spills? What is the overall operational cost to control oil spills in the country?

(d) **Fish Farming**. What is the impact on food and work availability due to not having decided on potential fish farming areas in the country? What is the effect of fish-farming due to restrictions in navigable areas?

(e) **Tourism**. What is the cost of closing a marina in for a certain period of time due to grounding of a vessel? What is the operational cost of a marina? Should not we consider periodic surveys to ensure safety and environmental health?

(f) **Cable laying**. What is the cost of adding 100 meters extra due to the non availability of proper hydrographic information of the country? What is the cost of replacement of damage section of the cable due to lack of a nautical chart shown precisely where the cable has been laid-out? Please compare any imaginable figure associated to the above activities with the budget estimates for some national hydrographic service: 1M Euros (Sri Lanka); 1.7M Euros

(Mozambique); 3.5M Euros (Chile); 7M Euros (Portugal); 11M Euros (Finland); 23M Euros (Norway); 43M Euros (Australia) (Approximate values in millions of Euros based on information reported to the IHB for the IHO Year Book).

Thus it can be concluded beyond doubt that establishing a basic National Hydrographic Service of appropriate dimensions will contribute to the maritime sector progress of any maritime country.

3.3.4 **Deductions**. With the above discussions on requirement and efficacy of a dedicated national hydrographic service, following may be deduced:-

(a) Hydrographic data and information is required to produce nautical charts as well as to contribute to the decision making process on many other different activities that take place in and on the sea.

(b) Hydrographic activities are taking place due to different needs no matter the in-existence of a national hydrographic service. Different government agencies will end up spening part of their budget hiring "pieces and bits" without any national coordination.

(c) Not being an agency in charge of keeping the data and information collected by different projects, a cost recovery policy cannot be implemented. It is not exploited the idea that data collected can be used for other purposes today and for sure, tomorrow.

(d) A National Hydrographic Committee or similar coordination structure, composed by all stakeholders needing hydrographic information is required to define the size, mission, objectives and policies of the National Hydrographic Service, as well as its annual work program.

(e) A National Hydrographic Service is a "must" for any maritime country with the willingness to offer its citizens the advantages of having the sea as part of its territory.

(f) One of the objectives of the IHO is to tender guidance and advice to Maritime States engaged in setting-up or expanding their hydrographic services.

3.4 **What is the importance of Hydrographic Information and its Influence**[23].

The International Hydrographic Organization (IHO) is an intergovernmental organization with a consultative and technical character, contributing to safety to navigation and protection of the marine environment through the coordination of the activities of National Hydrographic Services. The organization seeks for the greatest uniformity of nautical charts and complementary publications, as well as the adoption of the safest and most efficient methods of conducting hydrographic surveys and production of nautical charts. The IHO has a structure that comprises of a Conference – meeting of all member states, today 80; a Secretariat the headquarters of which is in the Principality of Monaco, 15 Regional Hydrographic Commission, including the Meso American and Caribbean Sea Hydrographic Commission at which Costa Rica as well as all Central American countries can participate. Also the IHO has different Working Groups, Committees and Commissions to deal with technical specific topics. One of the Committees is the Capacity Building Committee that looks after the improvement of existing hydrographic capabilities and develop strategies to establish new hydrographic offices where they do not exist, provided that expression of interest are received from interested countries. The IHO is doing a great effort in raising awareness on the importance of hydrography worldwide and this FIG Regional Conference was identified an excellent opportunity to flag this matter in a region where hydrography does not look to be developed, despite of the maritime characteristics of the countries in Central America.

[23] https://www.fig.net/resources/publications/figpub/pub57/pub57_article03.pdf

For senior hydrographers and hydrographic surveyors the comments made here are no surprise, but it is a reiteration and an opportunity to call for a higher priority to an activity that contributes to sustainable development for national and regional initiatives of economic importance. Safety of navigation and protection of the marine environment cannot be achieved without a national hydrographic agency and a coordinated structure. Hydrography needs to be seen as a national objective of strategic importance. Let us go through some early definitions that shall help us to get a better understanding of the importance of hydrography. There might be several definitions for Hydrography, however considering the purpose of this paper, the definition adopted by the International Hydrographic Organization has been taken. This definition says that:-

> *"Hydrography is that branch of applied sciences which deals with the measurement and description of the features of the seas and coastal areas for the primary purpose of navigation and all other marine purposes and activities, including –inter alia- offshore activities, research, protection of the environment, and prediction services".*

In this context, first of all let us identify some of the main hydrographic information referred here, those we think are of great general value; what type of activities can be benefited from the hydrographic information to finally attempt to give some thoughts as regard to the influence this information plays in the decision making process. From our perspective we also differentiate hydrographic data from hydrographic information, being the later the result of a process that makes the original raw data of use for a particular purpose. In this context we shall consider nautical charts and nautical publications as the two main traditional products compiling hydrographic information. It might be prudent to consider the definition of these two elements given by the International Maritime Organization (IMO), for which:

> *"Nautical chart or nautical publication is a special-purpose map or book, or a specially compiled database from which such a map or book is derived, that is issued officially by or on the authority of a Government, authorized Hydrographic Office or other relevant government institution and is designed to meet the requirements of marine navigation."*

> *"Refer to appropriate resolutions and recommendations of the International Hydrographic Organization concerning the authority and responsibilities of coastal States in the provision of charting in accordance with regulation 9."*

It is difficult to find a maritime country that does not depend on the availability of nautical cartography. It might be said on the contrary that almost all maritime countries are strongly dependent on nautical cartography and nautical publications for their maritime commerce and development. Nevertheless, it is extremely difficult to make an analysis that could easily show the economic benefit for a country derived from the use of these two information sources. Products such as Nautical Charts and Nautical Publications have some very interesting characteristics from an economic perspective that make any economic analysis a challenging exercise. They are:-

(a) An intermediate good
(b) Almost always a good from the public sector
(c) A public good or a public service

A nautical chart or nautical publication is an intermediate good as on its own has little utility and therefore must be incorporated to another good, activity or service, to have a real economic value. As an example, a paper chart is just a paper with information. Its value only becomes important when it is used, for example in the shipping activity, but a paper chart on a shelf in a store worth very little.

Being a good almost always prepared by the public sector, it is very difficult to quantify its value as they are marketed by the national authority or dealers with a referenced price. Also, are subject to subsidies the costs of which are normally very difficult to determine. Being a public good or a public service, its value cannot be determined precisely and this situation precludes the private sector to participate in 100% of the full process, from the planning to the provision of the product. Finally there is no competence in the consumption, that is to say that the service provided to one user can also be provided to many other users without an extra cost. The edition of a nautical chart or the provision of the marine safety information service constitutes a product and service the costs of which are independent of the number of users. Also, a person might decide not to use the service, but the service must be provided anyway as regulations request the use of nautical charts and publications for safety to navigation purposes, independent of the number of users.

The last particularity of these services is that they cannot be refused; for example, a mariner will pay for the services of lighthouses in a particular route, no matter if he decides not to use the service. Normally Hydrographic Offices sell their products at a marginal cost, that is to say, to recover the printing costs and the manpower used in the editing and printing phases. The recovery of costs such as ship's days, helicopter's hours, salaries of those gathering and processing the data, instrumentation maintenance and others, normally are not considered. Having discussed the above introduction about the importance and influence of hydrographic information, let us discuss some details.

3.4.1 **Primary Hydrographic Information**. The nautical chart and the nautical publications contain a complete set of information aiming at providing the mariner with the required information to sail and navigate safely. Following are some of these information:-

(a) **Coastline**. For mariner the representation of this line in the chart serves as a reference to interpret the representation offered by the radar, getting a good feeling of the ship position. But also this is the natural limit between the sea and the land at a particular moment, low water as marked on large-scale charts officially recognized by the coastal State. This line constitutes the normal baseline of a country and the bases for the establishment of the straight baselines, if apply according to UNCLOS. From here it is measured the breadth of the Territorial Sea, Contiguous Zone and Economic Exclusive Zone (EEZ) and the Definition of the Continental Shelf external limits or extension beyond 200 nautical miles if applicable. Also constitutes an important limit for the definition of the beach and the neighbouring proprietary of the land, either of public or private domains.

(b) **Coordinates**. The coordinates provide the mariner a standardize language to indicate his position, normally in degrees of latitude and longitude. This standardized system allows assigning each feature its corresponding coordinates. This coordinates are universally well known and facilitates delimitations, measurements and planning for different purposes.

(c) **Currents**. The indication of the currents in the chart and its description in relevant nautical publications provides the mariner with the conditions he might expect during his voyage in different places and at different times. Also this information is requested for all submarine operations, coastal engineering works, and many others, as it will provide a forecast of the direction and speed of the current expected. Normally the information provided in charts and publications correspond to the mean values extracted after long observation periods. Hydrographic Offices might have detailed records of current observations available for other uses.

(d) **Depths**. Depths provided in the nautical charts as well as the isobaths constitute an extremely valuable information, as they set the bathymetric characteristics of a particular sea area. The steepness or the flatness of the sea floor as well as the actual clearance between the sea surface and the sea bottom could be extracted from this information. It must be understood that not all the information can be made available in the nautical chart and much more information in the form of profiles are with the hydrographic offices that collected and processed the data.

(e) **Geographic description**. A nautical chart is self-explanatory, but there is information that must be made available in written form as it constitutes a geographic description of a particular area. One of the nautical publications that contains such description is known as Sailing Directions. In truth the description is an historical record or compilation of experiences offered by the hydrographers that surveyed the area and many mariners, port authorities and others that have contributed to enrich the description of the area. This benefits the mariners sailing the area for the first time as well as others aiming at knowing the particularities of the area for different uses.

(f) **Limits**. A nautical chart and the complementary nautical publications draws and describes, respectively, the different limits established for different purposes. It can be international maritime limits; other administrative limits as in UNCLOS; or national resolutions as for example areas forbidden for a particular activity or areas where a precise activity shall take place. This information is of the utmost importance as the situation is opposite to the land situation, where the limits are materialized with clear marks and indications. Limits also contribute to the management and protection of marine spaces.

(g) **Navaids**. The information on aids to navigation that are included on charts and publications represents identifiable marks that physically exists or systems that could provide a standardize position to a user. Also can be a service contributing to the safety of live at sea or to safety to navigation.

(h) **Sea bottom**. It is a characteristic of the nautical chart to indicate the type of the first layer of the sea bottom. This information helps the mariner mainly to decide where to anchor. Also where landing crafts could land in the shore. Information collected by hydrographic offices could be much complete than the general information included in the chart.

(j) **Tides, Levels and Datum**. The information on tides, the different levels adopted and the identification of the datum selected in the vertical control go all together. Long period of tide observation and the determination of the respective levels such as the Mean Sea Level, or any other, together with the adopted datum for depth reduction are decisions taken at each hydrographic office. A nautical chart indicates certain tides parameters and the datum. A special nautical publication known as tide tables provides the forecast for heights of the tide at relevant ports. Hydrographic Offices might have detailed records of tide gauges observations available for other uses.

(k) **Wrecks**. This information included on the nautical chart prevents from hitting a sunken ship of which no evidence is seen from the surface of the sea water. Its precise position and clearance could avoid accidents, lost of fishing equipment and nets and collisions, with unexpected results.

A very brief description of each of these 10 elements were provided above, included in nautical charts and nautical publications, highlighting the use a mariner makes of each of this information. The effort different national entities made to gather, process and generate hydrographic information, products and services is not trivial. The important message is to understand that this effort is a "national" effort. The cost/benefit ratio of the investment required for this to happen is improved if the information is shared and all potential national users benefit from this information to support their particular objectives. This requires a national coordination structure in the form of a National Hydrographic Committee or similar body. By the way, all countries signatories of the Safety of Life at Sea Convention (SOLAS) and members of the International Maritime Organization (IMO) have agreed to undertake several obligations as regard to the provision of charts, publications and services. This matter is no longer of a voluntary character but a commitment of maritime countries. A close reading to this regulation accepted and adopted by signatory countries is highly recommended. In the next section each of these elements will be associated with some key activities of relevance to maritime countries.

3.4.2 **Activities that benefit from Hydrographic Information**. **T**he following Table is a cross-referenced Hydrographic Information and the activities that benefit from that information. Certainly the list is not exhaustive, but gives an indication as regard to the main areas.

Hydro information activity	**Coastline**	**Coordinates**	**Currents**	**Depth**	**Geo Description**	**Limits**	**Navaids**	**Seabottom**	**Tides,levels & datum**	**Wrecks**
Aquaculture	√	√	√	√		√		√	√	
Cable/pipe laying	√	√	√	√	√	√		√	√	√
Coastal zone management	√	√	√	√	√	√	√	√	√	
Defence	√	√	√	√	√	√	√	√	√	√
Dumping		√	√	√	√	√			√	
Coastal engineering	√	√	√	√	√	√		√	√	√
Environment	√	√	√	√	√	√		√	√	
Fisheries, living resources	√	√	√	√	√	√	√	√	√	√
Marine delimitation	√	√		√	√	√		√	√	
Marine scientific research	√	√	√	√	√	√	√	√	√	√
Maritime transport / navigation	√	√	√	√	√	√	√	√	√	√
Natural hazard / modeling	√	√	√	√	√		√	√	√	
Non living resources	√	√	√	√	√	√		√	√	√
Ports	√	√	√	√	√	√	√	√	√	√
Real estate	√	√	√	√	√	√			√	
Safety of life at sea (SAR)	√	√	√	√	√	√	√			√
Sports	√	√	√	√	√	√	√	√	√	√
Tourism	√	√	√	√	√	√	√		√	√

3.4.3 **Influence of Hydrographic Data in decision making process**.

(a) **Aquaculture**. National Authorities when adopting rules to administer this activity shall consider the characteristic of the coast, the adjacent bathymetry, currents and tides. Without this basic information concentration and distances between centres to avoid mutual interference cannot be seriously adopted.

(b) **Cable/Pipe Laying**. Precise bathymetry, sea floor bottom characteristic and current are essential for planning the layout of cables and pipes laying. Environmental characteristics such as currents have strong influence in the route to be followed in the laying process operation.

(c) **Coastal Zone Management**. A precise description of the coast and the consideration of bathymetry, currents, and tides are required to adopt administrative measures for a better planning. The use of the coastal zone needs to prioritised and regulated in function of its particular characteristic. Questions such as which is the best use or what type of activities can coexist require an in depth study of these parameters. Criteria to manage and control maritime concessions are also dependent on hydrographic information.

(e) **Defence**. Naval exercises and operations require an excellent knowledge of the whole spectrum of hydrographic information. Special submarine exercise areas are to be defined and probably limitation for other activities shall be determined based on bathymetric characteristics of the area.

(e) **Dumping**. Dredging operations are commonly executed in almost all ports. Following strict criteria the dumping areas are to be defined, based mainly on depth, currents and ecosystems present. Dredges cannot discharge material elsewhere, but in areas predetermined and authorized.

(f) **Coastal Engineering**. The study of the coast line and the influence of tides, currents, waves and the bathymetry constitute a must in all coastal engineering projects. The impact of any work on the coastal dynamics needs to be assessed through models for which detailed information in mandatory.

(g) **Environment**. Environment is at permanent risk of accidents and plans are required to react in case of emergencies. By knowing the characteristic of the area the administration can adopt the most effective measures to control pollution.

(h) **<u>Fisheries & Living Resources</u>**. The fishing activity is very dependent on the bathymetry. Serious accidents could take place if the submarine topography is ignored as nets can be get caught by pinnacles or wrecks if not known. Administrative measures to protect certain species or to regulate its catch are as well bathymetric dependent.

(j) **<u>Marine delimitation</u>**. Nautical charts are vital for the establishment of maritime delimitations as requested by UNCLOS. Bathymetry and the characteristic of the sea floor sediment's layers are mandatory to access to extension to the continental shelf beyond the 200 nautical miles. The decision making process in this case has a strong international impact.

(k) **<u>Maritime Transport / Navigation</u>**. Navigational routes are determined based mainly on the bathymetric characteristics of the area. Routes must provide ships a safe clearance and sufficient manoeuvring area for the operations, especially in restricted waters, due to the narrow of the passages, the existing depths and currents. Nautical charts, representing all the required hydrographic information for this purpose, is considered to be main aid to navigation.

(l) **<u>Natural Hazard / Modelling</u>**. The success in protecting coastal communities from natural hazards such as tsunamis and storm surges are dependant on the availability of hydrographic information. Planning evacuation routes requires inundation charts that are prepared after running models based on some parameters and under some conditions. Coastal bathymetry and topography are a must in this approach.

(m) **<u>Non Living Resources</u>**. The decision to exploit marine non-living resources is also dependent on the geomorphology and characteristic of the sediments of the sea floor. The extraction of mineral or as simple as the extraction of sand to nourish rocky beaches demands a detailed knowledge of the regime that affects the coastal zone, such as depths, tides and currents.

(n) **Ports**. Ports are extremely important national economic units. The exploitation of the best draft a cargo ship can have obliges to have a detailed command of two basic elements, bathymetry and tides. This information is nowadays monitored in real time to optimize the cargo limitations. As regard to the exploration of areas apt for the development of new ports, the full set of hydrographic information is vital for a wise decision.

(p) **Real Estate**. As in land, the coastline and also the sea are exposes to a high pressure of increasing uses. New regulations and policies are put in place and innovative figures are demanding as well innovative legislations. E.g Artificial islands , the hydrographic information is mostly required to set standards and new practice in the administration and control of such spaces.

(q) **Safety of Life at Sea (SOLAS)**. Search and Rescue operations are well known. People and means participate in this normally risky operations. A complete hydrographic knowledge of the area of the emergency is required and special hydrographic missions are conducted whenever are necessary to support these activities.

(r) **Sports**. The definition of areas apt to practice nautical sports also should consider hydrographic information, such as bathymetry, currents and coast line. Sports at sea can take different forms. They can be on surface or submerged and therefore to authorize any particular area, this one must be specially examined according to the environmental conditions, minimizing risks.

(s) **Tourism**. There is a difference to be considered between shipping routes and cruise liners routes. The objective of the first is to transport goods from one port to another in the most safely and economic way (shorter route). Cruise liners privilege the scenery, the beauty. The identification of potential new routes and finally the decision to open new routes depend on hydrographic information.

It is evident that hydrographic information is absolutely necessary to adopt a number of decisions, all of which have an economic impact on the development of maritime nations.

3.5 **Summary**.

(a) The International Hydrographic Organization provides all maritime countries the opportunity to benefit from its experience in improving or establishing national hydrographic capabilities. Due to the incipient or lack of national hydrographic structure in several countries in Central America, countries as for example Costa Rica, might wish to consider approaching to the IHO bodies, to get advice on how Hydrographic Services as established in SOLAS Regulation 9 could be achieved.

(b) Capacity building is a key issue to achieve development. IHO structure considers regional hydrographic commissions to address regional problems for which a collective solution could be explored, identified and put in place. Countries in Central America should strongly consider participating in the activities of the Meso American and Caribbean Sea Hydrographic Commission and apply for technical support to develop its hydrographic capabilities.

(c) Hydrographic Information the traditional representation of which constitutes the nautical chart or nautical publication has an immense value. The concept that hydrographic information only serves the purpose of producing these two products is wrong. Being the main purpose to contribute to safety to navigation and protection of the marine environment, hydrographic information strongly contributes to many other initiatives of economic interest.

(d) The lack of hydrographic information precludes national authorities to adopt the best possible technical and administrative regulations aiming at the development and welfare of their communities in a sustainable manner. Funding hydrographic surveys and studies shall not be considered as expenditure but as an investment, and a real national asset of strategic importance.

3.6 **Conclusion.** Despite the comprehensive justifications offered above, when allocating funds to requirements, governments often give a low priority to hydrography. The reasons range from a lack of interest or a lack of understanding to the pragmatisms of political survival. Investments in national infrastructure, in genuine public goods such as hydrography, just don't attract the populist gratitude of a tax reduction or a welfare handout, neither do they satisfy the feel-good sentiment of an industry sector assistance package. Hydrographic infrastructure provides benefits to the nation as a whole and not to any one lobby group in particular. Investing in hydrography saves lives by making navigation safer, it enables maritime activities that support national security and economic prosperity while contributing to protection of the environment. It is akin to investing in infrastructure and insurance, perhaps not very exciting but invariably a very sound investment. The point here is not to argue that every coastal State should establish its own hydrographic organization as the investment and personal resource costs may exceed the capacity of many developing States. The point here is to bring out the high national value of hydrographic services and where such capability is beyond a nation's own means, it recommends the provision of hydrographic support as a prime area for a cooperative bilateral arrangement or foreign cooperation. It also emphasizes the criticality of national governments recognizing the value and importance of hydrographic information and putting in place arrangements that ensure any hydrographic information collected within that nation's waters is contributed to the national hydrographic database. Finally, the endeavor here has been to provide supplementary information that can be used to overcome at least one of the impediments to hydrographic investment referred to above, the deficiency in knowledge. It provides a comprehensive overview of the 'public good' benefits and intrinsic economic values of hydrography. This information may assist in imparting the importance of the requirement for hydrographic surveys among government officials. In doing so it also provides arguments to support the provision of hydrographic infrastructure as a viable, effective and indeed attractive avenue of providing external aid to developing coastal States.

CHAPTER 4

INDIAN NAVAL HYDROGRAPHIC DEPARTMENT – SETUP AND CAPABILITY

"Your Knowledge must become your capability."

- Carl von Clausewitz

4.1 **BRIEF HISTORY.** The Hydrographic Department of the Indian Navy derives its origin from the charting activities of the British East India Company, way back in the17th century. John and Samuel Thornton, Hydrographers to the East India Company compiled the first chart and Sailing Directions for the Indian Ocean in 1703. During the next two centuries, the captains of the ships of the East India Company went on to pioneer the charting of the Eastern seas extending from Red Sea to Persian Gulf, Arabian Sea, across the Indian Ocean right up to the China Seas. On the dissolution of the East India Company, the Indian Marine Survey Department was established at Calcutta in 1874, which became a part of the Royal Indian Marine in 1882.

4.1.1 Post independence the Department continued to carry out its functions under the Surveyor-in-Charge of Marine Survey of India from Bombay. On 01 Jun 1954, the Marine Survey Office was shifted to Dehradun and was renamed as the Naval Hydrographic Office, and Surveyor-in-Charge was re-designated as Chief Hydrographer of the Navy. The designation of Chief Hydrographer was once again changed to the Chief Hydrographer to the Govt. of India in 1964, in keeping with his growing national responsibilities. The Naval Hydrographic Office was re-christened in 1997 as the National Hydrographic Office in recognition of its national stature and increasing international role. The Indian Naval Hydrographic Department (INHD) has thus completed over 300 years of hydrographic surveying in Indian waters and the National Hydrographic Office celebrated 50 years of dedicated service to marine safety in the Indian Ocean on 01Jun 2004.

4.1.2 National Hydrographic Office is the National Authority for publication of nautical charts and publications. Over 90% of the world trade takes place through the sea and with removal of trade barriers; the volume of trade is ever increasing. As part of International responsibilities this office provides coverage for marine safety information in the region comprising of Indian Ocean, Arabian Sea and Bay of Bengal.

4.1.3 Over the years the economic pressures have resulted in the deployment of deep draught vessels, thereby the margin of safety for under keel allowance is continuously reducing. This has placed enormous demand on more accurate and up to date Hydrographic information. The data collected by modern surveying vessels undergo rigorous verification for Quality Control before it is provided to mariners in the form of Nautical Charts. As the dissemination of marine safety information is very vital, the INHO promulgates round the clock Navigational Warnings through Global Maritime Distress and Safety Services (GMDSS) through International Maritime Satellites.

4.1.4 Information technology applications to Hydrographic products and services have led to major developments in the world of Hydrography. One is satellite based Maritime Safety information updating service. The other is Electronic Navigational Charts (ENC) using the IMO type approved Electronic Chart Display and Information System (ECDIS). These are cutting edge product of information technology applied to maritime navigation, and is part of the global movement of most human activity towards progressive adaptation of the galloping Information Technology. It is an intelligent and dynamic navigational information system designed to increase safety/efficiency of navigation at sea.

4.2 **The Organisation – Current Setup[24]**. The Naval Hydrographic Department is a part of the Indian Navy and is a national organisation with international repute which was established in 1954. The organisation provides hydrographic information and data in the entire spectrum of marine field. The department is headed by the Chief Hydrographer to the Govt of India. The headquarters of the Indian Naval

[24] http://www.hydrobharat.nic.in/views/index.php

Hydrographic Department is National Hydrographic Office (NHO) which is located in Dehradun, Uttrakhand. The Chief Hydrographer to the Government of India is the executive head of the Indian Naval Hydrographic Department. The Chief Hydrographer is a serving Vice Admiral rank officer from the Indian Navy. The Chief Hydrographer is also the coordinator for charting Area "J" in the North Indian Ocean and NAVAREA VIII coordinator. The Chief Hydrographer is assisted by a staff officer and the organisation is further divided into 6 divisions. The organizational chart of the INHD is as shown below:-

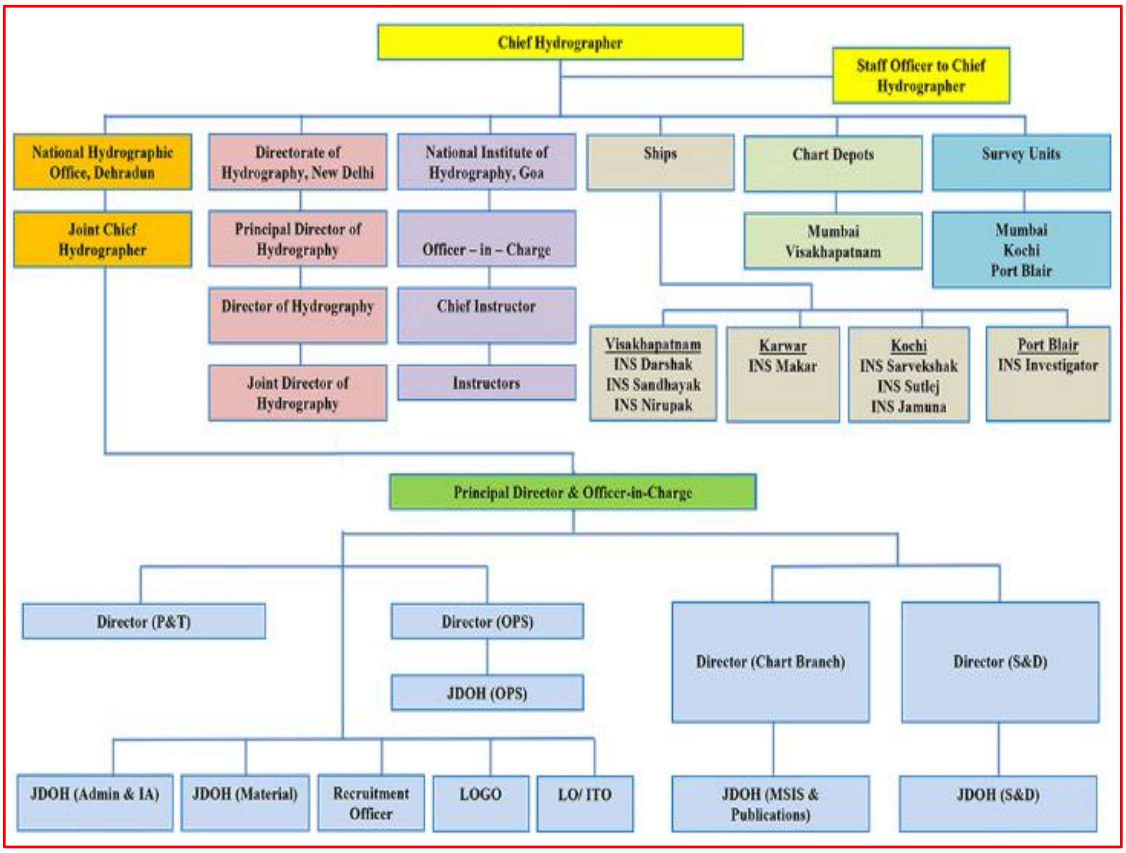

Fig 4.1 – Organisational Structure of Indian Naval Hydrographic Department (Source – Internet)

The peculiarities and the typical characteristics of the Indian Naval Hydrographic Department are discussed in succeeding paragraphs.

4.2.1 **<u>Nodal Agency.</u>** Indian Naval Hydrographic Department is being the nodal agency for Hydrographic surveys and nautical charting in India, has a very well established organizational setup. INHD has eight indigenously built modern survey ships fitted with state-of-the-art surveying equipment and a well established 'National Institute of Hydrography' which is recognized as the "Regional Centre" for imparting training in Hydrography for SE Asia by IHO.

4.2.2. **The Objective of National Hydrographic Department**[25] The objective of INHD is to provide information and data in accordance with IHO specifications, ensure that the client's requirements are adequately addressed for providing accurate hydrographic and oceanographic products with relevant analysis. Further to provide continuous product support to the user.

4.2.3 **Plans and Execution.** The field surveys are executed by eight fully equipped Oceangoing Surveying Ships and survey parties as per strict norms for surveys. "The Department has plans to have 12 such Ships, apart from Laser Bathymetry systems and separate field caravan survey teams under a 10-year perspective plan for the Department. Data collected by the ships is thoroughly examined at Dehradun by the Chief Hydrographer and published as charts and publications in total compliance with the International Chart Specifications and Formats. Computers and Automation towards data collection, analysis, examination and printing are increasingly being used. Constant interaction is being maintained with other National Hydrographic Offices and the IHO to ensure strict standards on products and services"[26].

4.2.4 **Expertise and Experience.** The National Hydrographic Department has produced 350 navigational charts and associated publication for safe navigation in Indian waters with the advent of digital technology. "The department also undertakes various surveys for development of new ports or other coastal facilities towards preparation of navigational charts, engineering feasibility studies etc. The department also conducts internationally recognised training in hydrography. Thus, the Naval Hydrographic Department supports marine development together with naval security of the nation" [27].

[25] http://indiannavy.gov.in/hydro.htm. (accessed on 29 Dec 18).

[26] http://indiannavy.gov.in/methodology.htm.(accessed on 29 Dec 18).

[27] http://mod.nic.in/samachar/dec15-20/html/ch2.htm.(accessed on 08 Sep 11).

4.2.5 **<u>The Strengths of INHD.</u>** The elements and components of INHD contributing to the strength of department are as follows:-

(a) National Hydrographic Office at Dehradun.

(b) National Hydrographic School at Goa.

(c) Eight Modern Survey Ships.

(d) Naval Chart Depots at Mumbai and Vishakapatnam.

(e) Hydrographic Survey Units at Mumbai, Kochi and Port Blair.

(f) Network of Chart Agents Spread over the Country for Sale of Charts.

4.2.6 The National Hydrographic Office has a fleet of eight oceangoing survey ships fully equipped with latest hydrographic, oceanographic geomagnetic and sea gravity sensors and one Catamaran Hull Survey Vesel (CHSV), INS Makar which was commissioned in Sep 12. Four more Survey Vessels (Large) are scheduled to join the surveying fleet in the near future. The department has acquired state of art survey and cartographic equipment to meet the demand of the mariners for more accurate surveys. Few of these equipment are as follows:-

S.No.	Equipments
A	Multibeam Echo Sounder
B	Single Beam Echo Sounder
C	Global Positioning System (GPS)
D	Differential Global Positioning System (DGPS)
e	Motion Sensor
F	Conductivity Temperature Depth (CTD)
G	Acoustic Doppler Current Profiler (ADCP)
H	Current Meter
J	Side scan Sonar
K	Total Station

L	Digital Level
M	Automatic Tide Gauge
N	Sound Velocity Profiler (SVP)
P	Grabs & Corers
Q	Sub Bottom Profiler
R	Water Level Meter
S	Autonomous Underwater Vehicle (AUV)
T	Remotely Operated Vehicle (ROV)
u	Automated Data Logging System (ADLS)

4.2.7 The various tasks undertaken by INHD are as follows:-

(a) Planning and issuing of Hydrographic Instructions for the conduct of surveys.

(b) Thorough data checking procedures for quality control for Chart production and Publications.

(c) Maintain a national data repository.

(d) Issue Notices to Mariners and Navarea Warnings for Navarea VIII for conduct of safe navigation in the dynamic environment.

(e) Undertake Project Surveys for clients.

(f) International Hydrographic Co-operation through training and foreign co-operation surveys.

(g) Conduct of international seminars for creating a learning environment and extend support.

4.3 **<u>Capabilities of Indian Naval Hydrographic Department</u>**. The hydrographic department of the Indian Navy has evolved over centuries, hand in hand with sea travel. While the early sailors navigated their ships, discovering routes by trial and error and documenting their precious information on closely guarded maps, the art of discovering safe routes grew into the highly specialized branch of hydrography. Kick started by the colonial businessmen, the department turned into a veritable hive of activity with the Indian Navy coming of its own post independence[28]. Having achieved the status of National Hydrographic Office, its role of looking out for the safety of mariners has expanded from a national to an international role- that of assisting the world community. Further the department rose to an organisation with international repute, having in-house expertise and capabilities to assist the countries of the world community by providing hydrographic services and training.

4.3.1 The data acquiring techniques have evolved over the years from use of rudimentary equipments like hand lead line, Sounding pole, Lucas sounding machine, sextants to modern Automated data logging systems, Side scan sonar, Multibeam data, sub bottom profiler, Remote sensing techniques etc. The erstwhile paper charts are giving way to Electronic Nautical Charts coupled with ECDIS, which will be the backbone of the marine community in times to follow. Today, the department is well established in discharging a wide spectrum of roles/ functions in national and international context. Some of these relate to:-

(a) Hydrographic and oceanographic support to Indian Navy and merchant marine

(b) Production of Navigational Charts and Publications including Electronic Navigational Charts.

(c) Disseminating marine safety information as Navarea VIII coordinator.

(d) Planning, co-ordinating and executing Hydrographic and Oceanographic surveys in Indian Waters.

[28] http://www.hydrobharat.nic.in/brief_history.htm accessed on 24 Dec 18.

(e) Assisting littorals of the Indian Ocean Region in capacity building efforts of their hydrographic infrastructure for littoral states.

(f) Undertake surveys for production of navigational charts, EEZ and continental shelf requirements.

(g) Hydrographic training as per IHO standards for Indian nationals as well as foreigners.

(h) Delineation of international maritime boundaries.

(j) Quality control of surveys carried out by other agencies in India.

(k) Interaction with various international organizations most noticeably the International Hydrographic Organisation.

(l) Regional hydrographic responsibility under IHO by initiating the establishment of North Indian Ocean Hydrographic Commission in 2002.

4.3.2 **National Hydrographic Office (NHO)** It is the apex institution, which is the nerve centre of the Naval Hydrographic Department. The data is compiled and processed, by experienced cartographers, using the state-of-the-art Automated Cartographic System for production of navigational charts, both in the conventional paper form and electronic digital form. It is here that the hydrographic surveys with a national perspective are planned and the annual task allocation of the survey ships/units is decided. The NHO has been designated as the National Marine Data Centre for hydrographic parameters as part of the National Ocean Information System. The Office has a modern state-of-the-art Repository for storage and archival of hydrographic and met-oceanographic data, both in conventional paper and digital forms. All surveying ships and units forward the data collected to this office where the Quality Assurance Section carries out stringent examination and review of the data to ensure compliance to international standards of the IHO/IMO. The Office is responsible for promulgation of navigational safety publication such as Notices to Mariners, List of Lights, and Nautical Almanac etc.

4.3.3 **Chart Production.** The Department has so far published a total of 385 charts covering the Indian Sub-continent including 330 Navigation Charts besides GEBCO (General Bathymetric Charts) and miscellaneous series charts. 102 large-scale charts are dedicated to the 13 major and 185 minor ports alone. The Department in addition also produces a series of 36 coastal navigation charts and other charts of required scales covering the entire Indian coastline. The endeavor of the Department is to provide good coverage of charts with latest data of less than 10-year vintage for the entire Indian waters. The Department is also in the process of digitizing all its existing navigational paper charts data for production of Electronic Navigational Charts (ENC). Till now 245 Electronic Navigational Charts have been made and are being marketed globally.

4.3.4 **Navigational Warnings.** The Radio Navigational Warnings for the NAVAREA-VIII are issued by the Chief Hydrographer to the Government of India. The Naval Chart Depot at Mumbai coordinates the broadcasting of all Navigational Warnings. All the updated warnings including the Notices to Mariners are available on the INHO website *www.hydrobharat.nic.in*.

4.3.5 **Indian Capability and Credibility**. Hydrographic applications in marine coastal development and environmental preservation, is a growth area, the world over. According to a UN study, approximately 50% of coastal states have no Hydrographic capability. Another 25% have only limited capabilities. Only the remaining 25%, including India, have adequate Hydrographic capabilities[29]. With a daunting coastline of 7516 kms, which is deeply indented at many places, to estuarine waters with marshy mangroves, vagaries of nature with tidal waters rising by 10 mtrs and inhospitable terrain of Andaman and Nicobar islands, the Indian naval survey ships have undertaken it all and come out with flying colours. In the past 60 years since independence, there has not

[29] Indian Naval Website http://indiannavy.nic.in/inhyco.htm accessed on 15 Dec 18

been a single instance wherein the data collected by the ships and depicted on the chart has ever come under any scrutiny. This has been possible as exacting standards are followed by the survey platforms which fulfill all international norms. The Indian Naval Hydrographic Department, thus, possesses wide experience with a long-standing tradition of professionalism, state of the art equipment, modern infrastructure and trained personnel. The stringent Quality Assurance & Quality Check (QA & QC) procedures should be given the required impetus and modern procedures be introduced to move ahead with the latest available technology.

Since past many decades National Hydrographic Office, Dehradun is involved in systematic and standardised collection of geo-referenced data pertaining to coastal configuration, depth of the sea in the areas of National Interest, seabed composition, wreck investigations, tide current and physical properties of water column, aids to navigation, marine traffic, fisheries etc. The data collected by the fleet of survey ships, is subjected to standardised processing for creation of databases to be used in marine environment preservation, exploitation of marine resources, definition of maritime boundaries (Law of the sea implementation) and scientific studies on sea and coastal zone. Periodic updating of these databases continues through fresh surveys. The office produces standard navigational charts and nautical publications as per conventions of the International Maritime Organisation (IMO) and the International Hydrographic Organisation (IHO). Since past few years, this department has been producing digital charts in the form of Electronic Navigation Charts (ENC) in accordance with specifications of IHO for use in the Electronic Navigation Chart Display and Information System (ECDIS) through a licensing system. The ENC, the database for ECDIS, is of high significance for the GIS application in the marine and scientific fields related to coastal, near shore zones, seas and oceans and are widely used by Mariners, Researchers, Scientists, Cartographers, Environmentalists, etc.

Hydrographic products and services have gone beyond the traditional scope of marine transport. Path breaking advances in Ocean Technologies in the past few decades, gave an impetus to industrisalisation and exploitation of the

Coastal and Offshore Zone. This in turn also led to environmental concerns for these zones. All these developments have added many new dimensions to value added hydrographic products and services. Beyond the traditional 'Safety of Navigation'; demands on Hydrography today, include Engineering Studies for Coastal infrastructure development, Offshore hydro-carbon and Ocean energy exploitation, Pollution Control and a wide range of Coastal Zone Regulation issues. The Indian National Hydrographic Office, Dehradun, has been contributing significantly to the march of India's coastal development by meeting these survey demands to world standards. Thus, besides providing the standard products and services for the marine community, the Department also provides customised products to various national agencies and research organisations related to ocean sciences and offshore resource exploration and exploitation. The thorough examination of wrecks along the coastal waters of India has also been one of the major activities undertaken by the Department. The Department actively assists in sea truthing programmes at sea for various scientific organisations.

4.3.6 **Survey and Clearance Efforts** There have been various instances, when the harbours have been closed post a calamity due to numerous sunken objects/ wrecks and underwater obstructions in the approach or the inner harbour and required a dedicated effort to firstly locate, then clear and finally reconfirm the absence of these dangers. The survey tasks are made even more onerous as the underwater objects are difficult to discern in the maze of destruction and need to be cleared at the earliest. In all the above cases, apart from rendering normal humanitarian aid and medical relief, the IN survey ships have simultaneously cleared the harbours through Herculean survey and diving efforts. This has on more than one occasion made the sea accessible, which enabled large scale induction and accessibility of facilities for the local populace.

4.3.7 **Training in Hydrography**. The shorter Oxford dictionary defines a Hydrographer as "one who is skilled in the science of the oceans; the science which has for its object the description of the waters of the earth's surface, encompassing the study and mapping of their form and physical features of the contour of the sea bottom and shallow waters etc". This basic definition together with the uncompromising demand from every mariner for precise information on the surface and of the features below the sea has but naturally thrust enormous responsibility on professional hydrographers and expects from them the very basic nautical tool for navigation to even consider any exploration for prosperity. It therefore only goes without saying that such high standards and quality of work can only be achieved if the men entrusted this responsibility of collecting and compilation of data for making of the nautical chart are both trained and groomed in the most professional manner.

4.3.8 **The National Institute of Hydrography (NIH)[30]**. The National Institute of Hydrography (NIH) at Goa, dedicated to meeting these stringent demands of the International community of mariners especially in the face of rapidly technological advances, has every reason to be proud of grooming reliable "Pathfinders for Seafarers". Besides having earned this International recognition for its professional pursuit the School is also honoured to be the Regional Training Centre for Hydrographic training for all of South/South-East Asian and African countries, a responsibility exceedingly well shouldered till date. The school is the only one of its kind in the country.

Established in 1959 as a fledgling unit in a tiny obscure corner of the present INS Angre at Mumbai, the then *"Hydrographic School"* has since grown from strength and has acquired International recognition in the past 60 years. The *"Hydrographic School"* was shifted in 1961 to Kochi under the aegis of the Indian Navy's Training Command and was eventually shifted to its present Location on the Alparqueiros hill at Goa in 1978. The choice of locating the school at Goa was quite apt considering the topography, coastal terrain, existence of water bodies close by and the availability of many wrecks and shoals in the waters, which provide the trainees with the best desired environment for all practical exposure, necessary for grooming of the Hydrographer. Furthermore with a 3.5 million dollar UNDP aid in 1980 the

[30] http://www.indiannavy.gov.in/nih/hi/node/31

"Hydrographic School" started realizing the broader vision envisaged by acquiring the latest hydrographic survey equipment of the era for training.

The *"Hydrographic School"*, since its inception has always endeavoured to ensure that the trainees undergoing the various courses are current with the various advancements taking place. With the introduction of new subjects and specializations of relevance during the revalidation of its Cat 'A' status in 1998, the school became the first country worldwide to offer "Industrial Offshore surveying" as a specialism, a further testimony to its academic prowess. Considering its expanding reach and status the *"Hydrographic School"* was rechristened as *"National Institute of Hydrography"* in 2009.

The Institute is the National training centre for Hydrography where courses for officers, sailors, and civilians, including personnel from abroad under ITEC program are conducted. The Institute is classified as the Regional Hydrographic Training Center for Africa, Persian Gulf and South East Asia Region and has already trained over 600 trainees from abroad apart from our own Indian Trainees. The Long Hydrographic specialization course conducted by the NIH leads to Master's Degree in Hydrographic Surveying and has also been awarded the Category 'A' and the Basic H course Cat B Certificate of Recognition by the IHO/FIG Advisory Board on Standards of Competence. The Institute is also ISO 9002 certified.

CHAPTER 5

INTERNATIONAL COOPERATION AND CAPABILITY GAPS IN INDIAN OCEAN REGION

5.1 With a robust organisation in place, a worlds class Hydrographic Office and eight ocean going survey ships equipped with the state of the art hydrographic equipment, a training institute running IHO certified courses the Indian Naval Hydrographic Department is a major player in the international hydrographic fora and a front runner in the region. The Department has been in great demand internationally for providing survey assistance, capacity building and training efforts for the countries of the region.

5.2 The hydrographic hardware available with India is comparable to the best. Coupled to this we have the best trained human resources in the field. The training being imparted at the National Institute of Hydrography which is accredited to the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors is always in premium amongst the South Asian countries provides world standards inputs. As a result the Institute has been declared a regional training centre for Africa, Persian Gulf and South - East Asian region. The clientele of the Institute has seen a steady increase of foreign students over the past few years.

5.3 The IHO has been encouraging International Hydrographic Cooperation among various countries, especially on a regional basis, to ensure an optimum utilisation of collective world hydrographic resources, both man and material, towards ensuring an adequate global hydrographic coverage. India being the leading hydrographic nation in the North IOR, has over the last few years, received a spate of enquiries from the countries of this region for hydrographic cooperation encompassing such aspects as conduct of hydrographic surveys in respective territorial waters, hydrographic/cartographic training, consultancy for setting up of hydrographic facilities /offices, maritime safety services etc. A number of initiatives have been progressed by NHD towards hydrographic co-operation in our areas of interest with long term strategic gains in mind.

5.4 India is also an active and influential member of the International IHO and has representation on its various committees. INHD fully supports the work programmes of the IHO, especially in developing regional expertise, and capacity building in Hydrographic Surveying and nautical charting in the littoral region. With experience and expertise in Hydrography coupled with modern instrumentation, India plays an important role on the International Hydrographic scene, where it promotes India's maritime interests notably on the issues of standards for global charts, Strategic Planning and Work Programmes of IHO and Global Maritime Distress and Safety Services (GMDSS). The Department plays an active role in promoting hydrographic cooperation in the region through the North Indian Ocean Hydrographic Commission (NIOHC) of the IHO; of which the Chief Hydrographer to the Government of India is the Chairman.

5.5 **Foreign Cooperation**. There is an immense scope and requirement for international co-operation in hydrography, particularly so, in Asia and Africa, where 36% and 64% of the waters respectively, are yet to be surveyed systematically. The IHO, an international organisation, which has a mandate to render guidance and advice to countries engaged in setting up or expanding their hydrographic services, to encourage co-ordination of hydrographic surveys with relevant oceanographic activities and to extend and facilitate the applications of oceanographic knowledge for the benefit of navigators, has a directed approach towards capacity building of the hydrographically developing member nations. India is therefore sitting on a veritable keg of opportunity since the majority of the countries of the IOR have a large deficit of hydrographic infrastructure and expertise.

5.6 Major initiatives have been taken in the past to further international hydrographic cooperation in the region. There has been an upsurge in the requests especially in the last 3-4 years and the Department has responded with alacrity befitting a leader. MoUs have been executed with Seychelles and Mauritius on hydrographic cooperation. The Department has undertaken 18 hydrographic surveys in Mauritius, Maldives and Seychelles over the last five years. These surveys have been highly appreciated and generated a swell of goodwill towards India. Regular requests continue to be received from these countries for assistance in conducting surveys, training of personnel and setting up of hydrographic infrastructure etc. The number of foreign participants to the NIH too has increased. On a request from Intergovernmental Oceanographic Commission (IOC) and IHO's Capacity Building Committee special courses for overseas students on latest survey technology have been conducted at the Institute on three occasions in the last one and a half years. Bilateral agreements have been signed with UK and Norway for distribution of the Indian hydrographic products. The Gulf Cooperation Council (GCC) countries too have evinced a keen interest in seeking assistance for survey operations and training facilities in India. Some of the ongoing and potential hydrographic cooperation projects are enumerated below:-

5.7 **Hydrographic Cooperation with Littoral States and Way Ahead**.

Few steps have been taken in the past to promote hydrographic cooperation internationally. The department has assisted various countries in the IOR in mapping their coastal areas and training manpower in hydrographic surveying. Other states beyond IOR have benefitted in terms of training, bilateral visits and sharing of technical expertise. First foreign survey was undertaken by INHD in 1993 for Government of Oman wherein two ships were deployed for a period of over six months and two surveys were undertaken on contractual basis.

Following the success in Oman, hydrography was identified as an important tool for Naval diplomacy. Assistance has been extended to countries in immediate neighborhood, island states in the Indian Ocean and coastal states in Eastern Africa who have no wherewithal or means to undertake these specialized tasks. These states also have large EEZs and the economies largely depend upon oceans, therefore requirement to chart the oceans is most critical. Apart from carrying out joint surveys (including surveys for continental shelf claims) the department has also engaged with other countries in terms of training, capacity building support and cooperation for enhancing the coverage for nautical products. The details of cooperation till now as discussed with the subject matter expert and after consulting the policy makers of hydrography along with the proposed way ahead for the future with each littoral states of IOR are discussed in the succeeding paragraphs.

5.7.1 **<u>Mauritius</u>**. India and Mauritius enjoy very strong cooperation in Hydrography since 2005, when MoU on hydrography was signed between the two countries during the visit of Prime Minister of Mauritius to India. It has since been renewed periodically and presently in force till 2020. Hydrography comes under the purview of Ministry of Housing and Lands (MHL) of Government of Mauritius (GoM).In the last 12 years, significant milestones have been achieved in hydrographic cooperation as enumerated below:-

(a) IN Survey Ships have completed ten survey deployments during which twenty six hydrographic surveys have been carried out.

(b) Seven charts and corresponding ENCs have been produced till date for Mauritian waters. Port Louis and Mathurin harbours, mainland Mauritius and outer Islands have been covered through these surveys. India has already been accorded Producer Nation status for Mauritius.

(c) In 2013, hydrographic assets (one Inshore Survey Vessel (ISV) and associated equipment for coastal surveys) were gifted to GoM during the visit of then Chief of Naval Staff.

(d) Since 2013, ***IN*** Hydrographic Training Team (INHTT) is assisting Ministry of Housing and Lands in establishing Hydrographic infrastructure, training of Mauritian personnel and mapping coastal areas around mainland Mauritius and outer islands.

(e) The hydrographic unit established in 2013 with Indian assistance has been re-christened as ‘Mauritius Hydrographic Service (MHS)’ in line with its national stature.

(f) 17 Mauritian personnel have undergone training at NIH, Goa.

(g) A new charting scheme which includes additional priority areas for GoM was agreed in 2015 and presently being pursued through joint surveys.

(h) Indian Line of Credit was announced in March 2018 for a Multi-purpose vessel which will have significant hydrographic equipment fit. The vessel is likely to be constructed by Goa Ship Yard Limited.

(j) Indian contribution in hydrography is well recognised and acknowledged at the highest level by GoM.

Way Ahead. The recommended way ahead for strengthening the cooperation with Mauritius is as follows:-

(a) Extension of MoU till 2030 to enable continued cooperation in hydrography.

(b) Progress charting scheme agreed in 2015 through conduct of fresh surveys and resurveys of areas which have undergone major changes.

(c) Provide hydrographic and oceanographic support to other stakeholders, such as scientific community, Ministry of Ocean Economy.

(d) Formalise the agreement on sale and distribution of Mauritian ENCs in the international market as proposed by GoM.

(e) Development and marketing of derived nautical products (for Mauritian waters) for tourism, fisheries and other applications.

(f) Continued deployment of INHTT for expansion of MHS to support mapping, nautical charting and Blue Economy initiatives around mainland Mauritius and outer islands.

(g) Hydrographic and Cartographic training for Mauritian Surveyors at NIH and NHO respectively under Indian Technical and Economic Cooperation (ITEC) Programme.

(h) Augment coastal mapping capability by providing advanced equipment such as shallow water Multi Beam Echo Sounder (MBES) and assistance in maintaining hydrographic assets because of limited support available in Mauritius for such specialised equipment.

(j) Provide assistance in selection/ procurement hydrographic equipment for multi-purpose vessel. IN personnel would eventually be required for operating the vessel and equipment as it has happened in the past for vessels constructed in India.

(k) Follow up hydrographic cooperation with assistance in other areas such as coastal erosion, wave modelling, aquaculture, fisheries, offshore exploration, and delineation of maritime zones etc. which are priority for a developing island state. A consortium of Indian government and private entities dealing with these issues could render valuable assistance and further strengthen the bilateral cooperation.

5.7.2 **Seychelles**. Even though Seychelles is an island state, it has been extremely reluctant in hydrographic matters. Seychelles Maritime Safety Administration (SMSA) under Ministry of Foreign Affairs and Transport-Department of Transport has coordinated Seychelles' membership of IHO in 2017. Though there is still no information about a designated national hydrographic authority, it is expected the organisation would be formed shortly and it would be under SMSA. Hydrographic cooperation with Seychelles commenced with signing of defence MoU in Sep 2003. Because of historical reasons UKHO is Primary Charting Authority (PCA) for Seychelles. It is observed that 04 of the 05 charts published by UKHO for Seychelles are based on old and imprecise survey information as old as 1875. The present status of hydrographic cooperation is as follows:-

(a) INHD has carried out seven surveys in Seychellois waters.

(b) A dedicated MoU on hydrography was signed between India and Seychelles in 2015.

(c) Under capacity building efforts 14 personnel from Seychelles have completed different Hydrographic courses at NIH Goa.

(d) Six charts have been produced for Seychellois waters covering important navigational areas and outer islands.

WayAhead. Considering the strategic importance of Seychelles, the recommended way ahead for gaining foothold is as follows:-

(a) Establish strong links with SMSA and the organisation designated for hydrography (under SMSA) in addition to Seychelles Coast Guard (SCG), during Joint Committee meetings.

(b) Coordinate with Seychellois authorities for recognition of charts produced by India as national series and 'INT' charts. Subsequently, other medium and small scale charts of Seychelles to be taken over from UKHO by updating them through fresh surveys.

(c) Mauritian model of hydrographic cooperation could be replicated by gifting hydrographic assets for coastal/ in-shore surveys and embedding a hydrographic training team.

(d) Depute INHTT for assistance in stabilising coastal hydrographic capability.

(e) Hydrographic training for Seychellois personnel at NIH under IITEC Programme.

(f) Capacity Building/ Training in cartography to be considered after coastal hydrographic capability is fully established.

(g) Agreement on development and marketing of derived nautical for tourism, fisheries and other applications associated with Blue Economy in accordance with requirements of local stakeholders.

(h) Assistance in strengthening MSIS procedures for streamlining flow of marine safety information to NAVAREA VIII coordinator (India).

(j) Follow up hydrographic cooperation with assistance in other areas such as coastal erosion, wave modelling, aquaculture, fisheries, offshore exploration, infrastructure development etc. to make a visible contribution in the maritime sector of Seychelles.

5.7.3 **Myanmar**. The mandate for charting and hydrographic surveys in Myanmar rests with Myanmar Naval Hydrographic Centre (MNHC). MNHC has three survey vessels and array of hydrographic and oceanographic equipment. MNHC aims to scale up its paper and ENC chart production through international assistance as most of the existing charts are need to be urgently updated. The cooperation between India and Myanmar has been strengthened considerably over the last five years. The significant developments in hydrographic cooperation are as follows:-

(a) One IN Survey ship was deployed to Sittwe Harbour, Myanmar for conduct of hydrographic survey in March 15.

(b) The successful deployment has led to further cooperative engagement between the two countries on matters related to INT charts, hydrography surveys and need is being felt to formalize the emerging hydrographic relations through MoU on hydrography.

(c) Till date 56 Myanmar Navy (MN) personnel have been trained various Hydrographic courses at NIH Goa.

(d) Two workshops on Cartography/ ENC production have been conducted at NHO, Dehradun for MN officers in 2016 and 2017.

(e) Myanmar has shared valuable data for revising Bay of Bengal Pilot.

Way Ahead. The recommended way ahead for strengthening the cooperation with Myanmar is as follows:-

(a) Formalise hydrographic cooperation between India and Myanmar through MoU.

(b) Training courses at NIH, Goa under ITEC programme. Short duration courses on MBES and other advanced systems in *IN* inventory.

(c) Assistance in streamlining ENC and Paper Chart production techniques, through workshops in India and deputing Mobile Training Teams to Myanmar.

(d) Joint surveys for updating existing charts and charting additional areas in Myanmar.

(e) Establish mechanism for sharing of data of Myanmar coast to update Indian/ INT charts of the region.

(f) Since Myanmar has been forthcoming in sharing the data with INHO, the cooperation could be taken to next level by providing charting cover for Myanmar national series and INT charts. This would have the dual benefit of generating immense goodwill and availability of IOR data with India.

(g) In the long term, sharing of ship building facilities for hydrographic vessels through self funding/ Line of Credit from GoI.

5.7.4 **Maldives**. Maldives neither is a member of IHO nor associate member of any Regional Hydrographic Commission. There is no hydrographic infrastructure available in the country. Ministry of Construction and Public Infrastructure (MCPI) was recommended as national authority during IHO national assessment in 2008. Till now, national authority for hydrography has not been designated, however IN has been cooperating with MNDF. Port authorities have been historically sharing data with UKHO to update charts and publications. Indian hydrographic cooperation with Maldives dates back to 2004 when a request seeking Indian assistance for setting up a hydrographic unit and undertaking surveys in Maldives was received from Government of Maldives. The progress made since 2004 is as follows:-

(a) IN ships have been deployed on four occasions for carrying out hydrographic surveys, during which five surveys were undertaken.

(b) Five navigational charts have been published for Maldivian waters.

(c) Nine Maldivian personnel have undergone hydrographic training at NIH, Goa.

Way Ahead. Bilateral relations have significantly deteriorated under the present Maldivian regime. The way ahead for hydrographic cooperation, once bilateral relations improve are as follows:-

(a) As a prominent NIOHC member, India may coordinate with IHO to carry out technical visit in Maldives for assessing present capabilities and recommend way ahead for developing hydrographic capability.

(b) Initially invite Maldives to join as associate member of NIOHC to provide a platform for bilateral/ multi-lateral talks, subsequently encouraging it to become full member of IHO.

(c) During bilateral meetings advise decision makers in Maldives to designate a national authority responsible for surveying. In the meantime existing links with MNDF be strengthened, and Port authorities be engaged to supply updates for Indian charts published earlier.

(d) Formalise hydrographic cooperation through MoU.

(e) Coordinate with Maldivian authorities for recognition of charts produced by India as national series and 'INT' charts. Subsequently, other medium and small scale charts of Maldives to be taken over from UKHO by updating them through fresh surveys.

(f) Training for Maldivian personnel at NIH, Goa under ITEC Programme.

(g) Assistance in strengthening MSIS procedures for streamlining flow of safety information to NAVAREA VIII coordinator (India).

(h) Provide essential hydrographic assets to kick start large scale shallow water data collection.

(j) Subsequently, depute INHTT for assistance in stabilising coastal/ in-shore hydrographic capability.

5.7.5 **Sri Lanka**. The National Hydrographic Office (NHO) of Sri Lanka was established in 1984 under the purview of National Aquatic Resources and Research Agency (NARA). Data collection and other surveying effort are provided by Sri Lanka Navy (SLN), whereas charting action is coordinated by NARA. UKHO has been aiding Srilanka under bilateral arrangement towards chart/ ENC production and marketing. SLN aims to take over entire operations of hydrographic surveys and chart production from NARA and a proposal for the same is pending with government.The hydrographic cooperation between India and Sri Lanka has strengthened significantly in the last few years and enumerated as follows:-

(a) A IN Survey ship was deployed for survey of Kankesanthurai harbour in 2013. It is to be noted that on 10 Jan 18 an agreement for Indian financial assistance for USD 45.27 million for upgrading Kankesanthurai (KKS) Harbour has been signed between two governments.

(b) In 2016-17 two more IN Survey ships were deployed for survey of Southern Coast of Sri Lanka and Weligama Bay.

(c) Till date 177 personnel from SLN has been completed various hydrographic course at NIH Goa.

(d) During 7th Navy to Navy Staff Talks, SLN has proposed conduct of afloat training for SLN Hydro Officers and specialized equipment training for SLN Hydrographic Branch personnel in India.

(e) ENC production workshop for three Sri Lankan Officers was undertaken at NHO in 2017. A similar workshop is planned in 2018.

Way Ahead. The recommended way ahead for strengthening the cooperation with Srilanka is as follows:-

(a) Engage both SLN and NARA for hydrographic cooperation as migration of entire charting operation to SLN may take considerable amount of time.

(b) Training courses at NIH, Goa and cartography workshops at NHO, Dehradun unde ITEC Programme. Short duration courses on MBES, AUV operations and other advanced systems in ***IN*** inventory.

(c) Joint surveys of entire Srilankan coast to update SL and Indian INT charts of the area.

(d) Assistance in strengthening MSIS procedures for streamlining flow of safety information to NAVAREA VIII coordinator (India).

(e) Establish mechanism for sharing of data of Srilanka coast to update West Coast of India Pilot and Indian/ INT charts of the region.

(f) Depute Training Teams for assistance in stabilising surveying capability and ENC production.

(g) In medium to long term SLN would required dedicated survey platform. The case for construction of survey vessel in India could be pursued through self financing or GoI Line of Credit.

5.7.6 **Kenya**. Hydrographic Services in Kenya are grossly under developed and there is negligible survey or charting capability. Kenya Hydrographic Service (KHS) under Survey of Kenya (SoK) (which in turn comes under Ministry of Lands) is the authority designated for hydrographic surveying, and Kenya Ports Authority (KPA) is a major stakeholder. For historical reasons, nautical charting of Kenya is looked after by United Kingdom Hydrographic Office (UKHO) as the Primary Charting Authority (PCA). Notwithstanding their modern appearance, the seven charts covering Kenya are based on old and generally imprecise survey information. A comprehensive chart updating programme is required for meeting the national requirements and international obligations. INHD is closely cooperating with Kenya on hydrographic matters since 2011 and progress made till now is as follows:-

(a) Ships have been deployed on six occasions for carrying out surveys.

(b) Four charts/ ENCs have been published by INHO.

(c) 12 officers from Kenya have undergone courses at NIH, Goa.

(d) MoU is being pursued which would open new vistas for the cooperation.

Way Ahead. Since Kenya has very close links with UKHO for charting requirements, it would require significant amount of efforts and resources from Indian side to establish long term cooperation. The recommended course of action for hydrographic cooperation is as follows:-

(a) Engage with KPA, KHS (and SoK) in addition to ongoing collaboration with Kenyan Navy.

(b) Officers from KHS and KPA could be invited for hydrographic training in India. It is to be noted that SoK had eleven IHO Cat 'B' Hydrographic Surveyors and one IHO Cat 'B' Marine Cartographer in 2012, however as the personnel have not been gainfully employed for hydrographic surveying till now, it can be assumed that the expertise has effectively been lost.

(c) Coordinate with Kenyan authorities for recognition of charts produced by India as national series and 'INT' charts. Subsequently, other medium and small scale charts of Kenya to be taken over from UKHO by updating them through fresh surveys.

(d) Once all the existing charts are renewed, a comprehensive charting scheme (for national series) could be finalised.

(e) Assistance in terms of equipment could be considered for developing limited coastal capability. For long term dependence, assistance INHTT could be deputed for establishing the necessary procedures and capacity building. Deep sea surveying capability and charting expertise may be retained with India.

(f) Streamline MSIS procedures and sharing of safety information with NAVAREA VIII coordinator, i.e. India.

5.7.7 **Tanzania**. Hydrography in Tanzania is at a nascent stage. There are primarily two organisations involved with hydrographic surveys, namely

Hydrographic Section of Tanzania Ports Authority (TPA) and Hydrographic Surveys Section within the Surveys and Mapping Division of the Ministry of Lands, Housing and Human Settlements Development (MLHSSD). MSIS is responsibility of Surface and Marine Transport Regulatory Authority (SUMATRA), however, the performance has been sub-optimal. It is understood that Tanzanian Navy is aspiring to develop capability to carry out surveys in future. TPA possesses limited capability to survey Ports and in shore areas using portable MBES and SBES. In 2014, MLHSSD procured a MBES system for surveying in shallow waters critical for navigation. Technical visit report by IHO in 2012 recommended MLHSSD as national authority for hydrography. For historical reasons, nautical charting of Kenya is looked after by UKHO. The highlights of the cooperation with India are as follows:-

(a) Ten surveys have been carried out by IN ships since 2013 mapping important harbours such as Zanzibar, Mkaoni, Tanga and Pemba.

(b) Six navigational charts and seven ENCs have been published based on these surveys. The charts produced by India have been recognized as national series charts by Tanzania.

(c) MoU on hydrographic cooperation has been signed with Tanzania and discussions are underway for establishing hydrographic infrastructure in Tanzania with Indian assistance, however financial implication of deputation has been a hindrance.

(d) Nine officers from Tanzanian Navy have undergone training at NIH.

Way Ahead. The recommended course of action for hydrographic cooperation with Tanzania is as follows:-

(a) The ambiguity on national authority could be taken up with stakeholders during the upcoming joint hydrographic committee meetings.

(b) Finalise Charting Scheme for Tanzania based on inputs from local authorities and implementation plan over 10 year period. The INT Charts presently being published by UKHO (based on old data) be systematically replaced by charts based on ***IN*** surveys.

(c) Develop domestic capability of Tanzania by positioning Hydrographic Training Team. The cost of deputation could be partly borne by India considering the strategic advantage of embedding the team in Tanzania.

(d) Formulating the plan for assistance in terms of hydrographic assets for developing coastal survey capabilities. For remaining requirements, consultancy services could be provided.

(e) Offering training slots for Tanzanian personnel (Navy and civilian organisations) under ITEC programme.

(f) Training on MSIS procedures and NAVTEX for personnel from SUMATRA either in India, or through Mobile Training Teams and streamline data sharing with NAVAREA VIII Coordinator (India).

5.7.8 **Indonesia**. Indonesia is one of the few countries which have a well established hydrographic office in South East Asia. Established in 1951, Pusat Hidrografidan Oseanografi Angkatan Laut (Pushidrosal) or Indonesian Navy Hydrography and Oceanography Center, is the National Hydrographic office of Indonesia. Pushidrosal has two survey ships equipped with modern surveying system including AUV and ROV. It maintains a folio of 538 paper charts and 508 ENC cells. Pushidrosal is also developing Indonesian Marine Geospatial Information Center (I-MaGIC) as implementation of Marine Spatial Data Infrastruture (MSDI). The office is also engaged in research in Satellite Derived

Bathymetry (SDB) in collaboration with (LAPAN) Indonesia National Institute of Aeronautics and Space (LAPAN). Indonesia has recently become full member of NIOHC, and has been closely cooperating with India in the past.The hydrographic cooperation between the two countries can be summarized as follows:-

(a) Two IN Survey Ships carried out joint hydrographic survey with Indonesian Hydrographic Department in Selat Bengala in May 2001 and Jul 02 respectively.

(b) India has played a significant role in training Indonesian officers, wherein 11 Officers from Indonesia Navy has been completed Cat 'A' and Cat 'B' Hydrographic courses at NIH Goa.

Way Ahead. Indonesia being a leading hydrographic state in South East Asia, the future scope of cooperation exists in areas of mutual interest. The future scope of cooperation is as follows:-

(a) Training slots for Cat 'A' courses at NIH as Indonesia does not have capacity for the same.

(b) Deputing Indian officers for Hydrographic courses in Indonesia (Cat 'B'), it is understood that Indonesia will commence offering the courses in English language in near future.

(c) Establish mechanism for sharing of data of Indonesian coast and joints surveys of areas of mutual interest to update Indian/ INT charts of the region.

(d) In the long term, sharing of ship building facilities for next generation hydrographic vessels through self funding/ Line of Credit from GoI.

(e) Reciprocal ship visits, joint training surveys and sharing of best practices.

(f) Experience sharing in terms of ENC Production, HPD, AUV operations, SDB and MSDI through workshops and delegation visits.

(g) Invite SMEs for visit to IN facilities to further hydrographic cooperation.

5.7.9 **Oman**. Royal Navy of Oman (RNO) is the national agency responsible for hydrography. It has a full-fledged hydrographic office and presently has one operational survey ship. Most of their officers are now getting trained in UK and Ireland, although in the past seven personnel were trained at NIH and few others in Malaysia. India and Oman have been closely cooperating during IHO and NIOHC meetings. The present status of hydrographic engagement with Oman is as follows:-

(a) IN carried out five month long contract survey off Omani coast in 1993-94.

(b) A IN Survey Ship visited Port Sultan Qaboos, Muscat to showcase IN's hydrographic capabilities at Defence Expo in 2008.

(c) A delegation from Oman visited NHO in 2014 for exploring avenues for cooperation; after which there has been no headway.

(d) Seven RNO Officers/ personnel have completed Cat 'A' and 'B' at NIH Goa.

Way Ahead. The recommended way ahead for strengthening the cooperation is as follows:-

(a) Cooperation in hydrography be included in the IN-RNO staff talks. Subject Matter Experts (SMEs) could be invited for a visit to NHO and NIH, followed by reciprocal visits to identify areas of cooperation.

(b) Joint surveys in deep sea areas for which Oman has limited capability.

(c) Training courses at NIH and ENC workshop at NHO could be offered for RNO personnel.

(d) Ship visits and exchange of personnel for training and sharing best practices.

(e) Establish mechanism for sharing of data of Omanese coast to update Indian/ INT charts of the region.

5.8 **Other Countries in IOR**.

5.8.1 **Cooperative Mechanism on Safety of Navigation in the Straits of Malacca and Singapore.** The Govt of Singapore and the IMO organised the 3rd IMO meeting on the issue of 'Enhancing Safety Security and Environmental Protection in the Straits of Malacca and Singapore' at Singapore in Sep 07. The meeting centered on the participation of the user state in six projects of the Co-operative Mechanism on safety of navigation and environmental protection in the Straits of Malacca and Singapore. These projects ranged from removal of wrecks from the Strait of Malacca and Singapore to replacement of aids damaged by the tsunami of Dec 04. The littorals sought aid / assistance of the user/neighbouring maritime states / organisations for undertaking these projects:-

(a) The Indian participation in the Project was steered by both MEA and MoD wherein India has indicated its participation with the scope as indicated below:-

(i) **Project 1 - Removal of Wrecks in the Traffic Separation Scheme (TSS).** 04 weeks course on bathymetry and wreck related aspects to be conducted at the NIH, Goa for nine personnel from the littorals.

(ii) **Project IV – Tide Current, Wind Measurement System.** India has taken on the responsibility of funding the complete project. The first stage payment of Rs. 3.81 Crores (US $ 7.74 Lakhs) has already been deposited in the concerned fund of the co-operative mechanism. India and China are to jointly render technical assistance and oversee the project till its completion.

(b) We are already committed to the above two projects. This active participation by India in the Straits of Malacca and Singapore is an indication the growing reach of the IN and the Indian interest in the region. Being part of this cooperative mechanism can open up new vistas for the Department in a region which till now has been largely ignored.

5.8.2 **Thailand**. Hydrography falls under the purview of Hydrographic Department, Royal Thai Navy or "HDRTN". From the national report, it is evident that Thailand has limited hydrographic resources, as it carried out only 04 surveys in its waters in 2017. It has three survey/ research vessels, two of which are very old i.e. 1961 and 1982 vintage.INHD has been engaging with Thailand Hydrographic Department during international conferences such as NIOHC and IHO meetings. Till date seven officers from Royal Thai Navy have completed Cat A and Cat B Hydrographic courses at NIH Goa.Future scope of cooperation is as follows:-

(a) Training courses at NIH, Goa. Short duration courses on MBES, and other advanced systems in *IN* inventory.

(b) Assistance in streamlining ENC and Paper Chart production techniques.

(c) Joint surveys for updating existing charts and charting additional areas in Andaman Sea.

(d) Signing of MoU on hydrographic cooperation.

(e) In the long term, sharing of ship building facilities for hydrographic vessels through self funding/ Line of Credit from GoI.

(f) Establish mechanism for sharing of data of Thai coast to update Indian/ INT charts of the region.

(g) Plan visit of SMEs to visit IN's training and charting facilities.

5.8.3 **Mozambique**. The National Institute of Hydrography and Navigation (INAHINA) is the Mozambican official Hydrographic Office (HO), working under the Ministry of Transport and Communications. Hydrographic activity is mainly limited to the main ports of Maputo (South), Beira (center) and Nacala (North) and several small harbors and inland waters. In the last few years, INAHINA has acquired necessary resources and infrastructure to carry out coastal surveys (using small survey boats and sensors such as single/ multi-beam echo sounders, side scan sonar etc.). INAHINA also publishes national series of paper charts (for main harbours) and aspires to develop ENC capability in the near future for which training assistance has been received from South Africa National Hydrographic Office (SANHO). It also collaborates with IHPT (Portuguese Hydrographic Institute) and UKHO for charting and capacity building requirements. INAHINA produces charts for pleasure crafts for certain areas. It is evident that Mozambique is on the path of developing domestic hydrographic capability. It is also actively collaborating with UKHO and IHPT (as both HOs have been historically active in charting Mozambican waters) and SANHO (leading regional HO in African region). IN carried out survey of Port Beira in 2009 to gain foot hold, however Mozambique continue to be under the strong influence of UKHO. Three Mozambican personnel have undergone hydrographic training in India. The recommended way ahead for cooperation is as follows:-

(a) Interaction with INAHINA at SAIHC and IHO meetings to improve bilateral relations and gauge the response towards Indian assistance.

(b) The SMEs could be invited for official visit to NHO, Dehradun and NIH, Goafor changing their changing their outlook.

(c) Training of personnel in Cat 'A' and 'B' hydrographic courses could be considered based on official request from INAHINA.

(d) Assistance for systematically charting the areas for which INAHINA does not have the capacity may be considered based on commitment from Mozambican authorities to enter into long term cooperation through MoU with India.

5.8.4 **Bangladesh**. Bangladesh Navy Hydrographic Department (BNHD) is vested with the responsibility of hydrographic survey in the coastal and offshore area of Bangladesh. Besides Bangladesh Inland Water Transport Authority (BIWTA) conduct surveys for inland waters. The BNHD consists of a fleet of five survey ships, Bangladesh Navy Hydrographic and Oceanographic Center (BNHOC) and BN Hydrographic School (BNHS). The Directorate of Hydrography at the Naval Headquarters is the national representative of Bangladesh to International Hydrographic Organization (IHO) and exercise functional authority over BNHD. A major boost was received in hydrographic capabilities with French collaboration in 1996 & 2000 through Hydro-Bangla I and II projects respectively. BNHD maintains a catalogue of 22 national series and 09 INT charts. INHD has been interacting with BNHD at IHO conferences and SAIHC meetings. 52 BN personnel have been trained at NIH, Goa. Basic 'H' of Bangladesh Navy is now recognized as Cat 'B' course in hydrography. The proposed way ahead for hydrographic cooperation is as follows:-

(a) Establish mechanism for sharing of data of BN coast to update Indian/ INT charts of the region.

(b) As INT Area 'J' coordinator, facilitate production of INT charts which are responsibility of BNHD.

(c) Reciprocal ship visits and sharing of best practices.

(d) Training of BN officers at NIH for Cat 'A' courses. Short duration courses on MBES, AUV operations and other advanced systems in *IN* inventory.

(e) Technical assistance in ENC production.

(f) In the long term, sharing of ship building facilities for hydrographic vessels through self funding/ Line of Credit from GoI.

(g) Streamline MSIS procedures and sharing of safety information with NAVAREA VIII coordinator, i.e. India.

5.8.5 **South Africa**. South African Navy Hydrographic Office (SANHO) was established in 1955 and is recognised as Centre of Hydrographic Excellence in Africa. SANHO maintains a folio of 109 paper charts, 57 ENCs and 9 publications. SA is also a prominent member of Southern African and Islands Hydrographic Commission. India and South Africa closely cooperate on hydrographic matters during IHO and SAIHC meetings. Nine trainees from SA have undergone courses at NIH, Goa. An IN Survey ship visited Cape Town in 2012 for interaction with SANHO and SAS Protea. Future scope of cooperation is as follows:-

(a) Cooperation in hydrography be included in the IN-SAN staff talks. Subject Matter Experts (SMEs) could be invited for a visit to NHO and NIH, followed by reciprocal visits to identify areas of cooperation.

(b) Establish mechanism for sharing of data of African coast to update Indian/ INT charts of the region.

(c) Free exchange of Charts/ ENCs for IN/SAN use.

(d) Ship visits and exchange of personnel for training and sharing best practices.

(e) Close cooperation at SAIHC for promoting hydrography in the South Western Indian Ocean.

5.8.6 **UAE**. The Military Survey Department (MSD) of UAE Armed Forces is responsible for hydrography in UAE. MSD is equipped with modern surveying equipment for shallow to medium depth surveys which are operated using small crafts. It also operates a LiDAR system (shoals 3000), which has not been very successful in UAE waters. There has been very limited interaction between NHO and MSD in the past. A delegation from UAE visited NHO in March 2018 and expressed interest in short duration training courses for officers and sailors. It is essential to increase the level of interaction through reciprocal visits before charting the course for further cooperation.The hydrographic cooperation is recommended to be included in next defence/ navy level staff talks.

5.8.7 **Iran**. Iran has a well established hydrographic office with four medium/ large hydrographic vessels under Ports and Maritime Organisation (PMO), which in turn is part of Ministry of Roads and Urban Development. All hydrographic activities are coordinated by Iranian National Hydrographic Committee (INHC). INHC/ PMO also has the capability of producing paper charts (42 INT charts) as well as ENCs (530 cells). The proposed way ahead for cooperation is as follows:-

(a) Ship visits and exchange of personnel for training and sharing best practices.

(b) Establish mechanism for sharing of data of Iranian coast to update Indian/ INT charts of the region.

(c) Training of Iranian personnel at NIH, Goa under ITEC programme.

5.8.8 **<u>Saudi Arabia and GCC Countries.</u>** Saudi Arabia and GCC Countries have shown great interest in Indian Hydrographic Department and its production facilities for ENCs and paper charts comparable to the best in the world and have sought assistance for a hydrographic survey in the Gulf of Oman and conduct of a Cat B course for participants from the GCC countries.

5.8.9 **<u>Australia</u>**. The Australian Hydrographic Office is the Commonwealth Government agency responsible for the publication and distribution of nautical charts and information required for the safety of ships navigating in Australian waters. It has well established set up for hydrographic surveys, charting and marketing of navigational products. Data collection platforms include 02 survey ships, 04 survey launches and 01 Laser Airborne Depth System (LADS). Three RAN Officers have completed Cat 'A' Hydrographic course at NIH Goa. An Indian delegation visited the Laser Airborne Bathymetry (LABS) division of Royal Australian Navy (RAN) in 2018. The recommended way ahead for strengthening the cooperation is as follows:-

(a) Exchange of trainees for Cat 'A' and Cat 'B' courses at NIH, Goa and RAN Hydrographic School in Balmoral Penguin.

(b) Establish mechanism for sharing the data of Australian coast and Antarctica to update Indian/ INT charts.

(c) Reciprocal ship visits, joint training surveys and sharing of best practices.

(d) Experience sharing in terms of ENC Production, AUV and LADS through ship/ delegation visits.

(e) Free exchange of Charts/ ENCs for IN/RAN use.

5.8.10 **Antarctic Survey Programme.** India is a member of the Working Group for cooperation in Antarctica under IHO program since 1992. As part of IHO Scheme, the Naval Hydrographic Department has formulated a seven-year survey programme to progress charting and oceanographic data collection in Antarctica waters, especially in the approaches to Indian Permanent Stations. Naval Hydrographic Team was deputed for the first time with XIVth Antarctica summer expedition in 1994-95 and onwards, which gained valuable experience in undertaking hydrographic surveys in Antarctica waters and gathered some useful hydrographic data.

5.9 There are numerous other countries in IOR such as Pakistan, Malaysia, countries in the Persian gulf, Yemen, Somalia, Djibouti, Saudi Arabia, Madagascar, Malaysia, Singapore and Egypt with which INHD has interacted occasionally on specific issues. Scaling up of cooperation with these countries would largely depend upon improvement in security situation (in some of these countries) and bilateral relations. The interaction could be systematically increased through bilateral talks and delegation level visits, which would determine the future course of action.

5.10 **INHD's Contribution at IHO[31]**. International Hydrographic Organisation (IHO), of which India is a member, is an intergovernmental consultative and technical organisation, which was established in 1921 to support safety of navigation and the protection of the marine environment. IHO has a professional and advisory role to International Maritime Organisation (IMO). Majority of aspects concerning safety of navigation, search and rescue, availability of mandatory charts, publications are steered through the co-ordination efforts of IHO prior advising IMO for promulgation and implementation.

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[31] https://www.iho.int/mtg_docs/rhc/NIOHC/NIOHC16/NIOHC16-06c-India_National_Report.pdf

India is an active and influential member of the International IHO since 1956 and fully supports the work programme of IHO. With experience and proficiency in Hydrography coupled with modern instrumentation, India plays an important role at IHO, where it promotes India's maritime interests notably on the issues of standards for global charts, Strategic Planning, Work Programme of IHO and Global Maritime Distress and Safety Services (GMDSS). India is one of the founding members of North Indian Ocean Hydrographic Commission (NIOHC) and has been chair of NIOHC on seven occasions in the last 18 years, thus steering the regional body to preserve Indian interests. The notable contributions of INHD at the level of IHO and other International Organisations are summarised as follows:-

(a) Commodore DC Kapoor was the first Chief Hydrographer to be elected to the Directing Committee of International Hydrographic Bureau (IHB) in April 1972. He served as Director in the Bureau till 1982.

(b) Rear Admiral FL Fraser served as the President of Directing Committee of IHB from 1982 to 1987.

(c) NHO was assigned the responsibility of preparing nine bathymetric plotting sheets by IHB, based on source material received from data centers world over. These were later incorporated in General Bathymetric Charts of the Oceans (GEBCO).

(d) India is a member of Permanent Working Group on Cooperation in Antarctica (PWGCA), later renamed as Hydrographic Committee on Antarctica, an organization set up under IHO in 1995. Personnel from ***INHD*** have been participating in surveys in Antarctica since 1994.

(e) The Chief Hydrographer to the GoI was elected as the member of Commission on the Limits of the Continental Shelf (CLCS) from 1997-2002.

(f) INHD's contribution towards preservation of marine environment through navigational safety surveys was internationally recognised by the

World Underwater India, Monaco. The first Laureate award (the GPIEM) for 2001 was bestowed on NHO and Chief Hydrographer.

(g) India was on the forefront in establishing North Indian Ocean Hydrographic Commission (NIOHC) in 2002 and Chief Hydrographer was elected as founder member of NIOHC. Since then, six meetings of NIOHC have been hosted in India, the last one being 18th NIOHC in Goa in April 2018.

(h) The Chief Hydrographer is responsible for navigational warnings to mariners in NAVAREA VIII, which covers almost entire Indian Ocean Region.

(j) INHD is INT chart coordinator for Area 'J' spanning from coast of Africa till Malacca Straits

(k) India is World Electronic Chart Data Base (WEND) observer and coordinator for proposed Regional ENC Coordinating Centre (RENC) North Indian Ocean.

(l) Member of UN Conference of Standardisation of Geographical Names, UN Committee for the Nomenclature of Ocean Bottom Features and UN Panel of experts on Hydrographic Surveying and Nautical Charting.

(m) Member of IHO Strategic Planning Working Group (SPWG), Advisory Board on Laws of the Sea (ABLOS), ENC Working Group, Nautical Information Provision Working Group (NIPWG), Nautical Cartography Working Group (NCWG), Crowd Source Bathymetry Working Group (CSBWG) and Tides, Water Level and Currents Working Group (TWLCWG).

(n) India is a member of recently formed IHO council (comprising 30 members), which is a highly empowered organ of IHO and was created in 2017 as part of restructuring of IHO.

CHAPTER 6

FUTURE ROLES OF HYDROGRAPHY IN INDIAN OCEAN REGION

Planning is bringing the future into the present
so that you can do something about it now.

- *Alan Lakein*

6.1 Traditionally, hydrographic data was used mainly for nautical charts. Hydrographic surveys are costly, and data should be used beyond navigation. Some have developed centralised hydrographic databases, but their only purpose is to produce charts. Hydrographic data should be used for other purposes too. Hydrographic data is the foundation for building a maritime data management system, in the framework of a Marine Spatial Data Infrastructure for broader use. Visionary organisations are already evolving their traditional roles and jumping onto the 'Big Data' ship and connecting to the World through web services. The use of Hydrographic data is evolving for good[32].

6.2 When someone mentions 'hydrography' most people think of nautical charts because its origins are found in safety of navigation. New technologies enable hydrographers to extract more information from collected data than just the sounding and what was 'noise' is today valuable data (backscatter). And even other collected parameters, such as sound velocity, temperatures and tides, were only used to correct soundings.

6.3 Hydrographers can process more data and bring faster and more accurate results with the new technologies and powerful algorithms; today the sources, magnitudes and variability of acoustic backscatter can be identified and interpreted, and models can be developed to obtain useful information, from seabed sediment classification to water

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32 https://www.hydro-international.com/content/article/the-new-role-of-hydrography-in-the-21st-century

column data. The factors which merit attention for further expanding/ strengthening the India’s hydrographic cooperation in the Indian Ocean Region and beyond are as follows:-

6.3.1 **<u>Prioritising Foreign Cooperation Initiatives</u>**. The assets available are comparable with the best in the world and continue to be in great demand internationally, especially in Asia and Africa. However, there is a need to prioritise the Foreign Cooperation (FC) initiatives for optimum utilization of resources and achieve desired outcomes in the long run. The existing prioritisation for FC promulgated by Indian Navy (***IN)*** (placed at **Annexure** to this chapter) could be tailored for hydrographic cooperation based on interaction with countries, their specific requirements in hydrography, strategic importance and quantum of resources required to make a significant impact.

6.3.2 **<u>Defining Scope and Outcome of Hydrographic Cooperation</u>**. While engaging with a coastal state, the main objectives of the collaboration in the long term need to be clearly defined. There could be multiple reasons of engaging a coastal state, such as demonstrating reach and capability of the ***IN***, producing charts and publications for the beneficiary state, simply sharing best practices and confidence building or strategic advantage of fulfilling the requirements of a particular country to wean/ keep it away from adversaries. Other issues such as data sharing/ ownership issues, recognizing Indian charts as carriage requirements for shipping, Producer Nation status, sharing of revenue from resultant products and the desired end state of the cooperation within the predetermined time frame need to be taken into account.

6.3.3. **<u>Identifying and Engaging with National Organisation Responsible for Hydrography</u>**. In most of the countries (as in case of India) Hydrographic Service is part of the state's Navy, because of the advantage of having personnel with appropriate sea experience for specializing in hydrography. Alternatively, other countries have found it convenient to create their Hydrographic Service within the structures of the Ministries of Transport or Fisheries or a Port Authority or as a part of the Ministry responsible for infrastructure, land survey and/or environment as they have no hydrographic assets and mapping is best understood by land surveyors. The latter is true especially in case of countries in East Africa and South Asia. For states with underdeveloped oceanic sector, there is usually no designated organization/ government authority, which may lead to a situation where two closely related agencies feel responsible for hydrography (and have divergent views on capacity building), or in other cases no organisation is willing to undertake the responsibility. In case it is an organization dealing with Land Survey etc. such organizations have their primary focus on land survey/ management, and there is a lack of understanding of oceans/ hydrography and the activities associated with it. In case the appropriate national authority is not engaged with, there is a possibility that expected outcomes are not achieved in the long term. The Indian embassies/ High Commissions can play a vital role in identifying and engaging with suitable agencies and establish long term cooperative mechanisms.

6.3.4. **Delivering Benefits Related to Hydrography**. One of the main reasons that hydrographic services of many coastal states have remained underdeveloped is that full economic benefits from such a national programme are not immediately apparent and thus decision makers are reluctant in making significant investments. This aspect is more relevant in case of SIDS, wherein publishing a chart alone is unlikely to lead to any appreciable change in volume of shipping or other advantages usually associated with hydrography. The decision makers look forward to benefits beyond mere charting of areas while engaging with another country in the context of oceanic domain. Such expectations range from climate change mitigation, inundation modeling, infrastructure development and exploration & exploitation of living/ non-living resources. If the tangible benefits do not follow hydrographic cooperation/ surveys, the long term success cannot be assured and the coastal state may lose confidence in the cooperation.

6.3.5. **Building Capacity of Beneficiary States**. A country which recognizes the importance of hydrography will have the natural aspiration to develop a credible domestic hydrographic capability in due course for which further support would definitely be sought from Indian government in terms of hydrographic assets, equipment and survey platform etc. Not rendering assistance may have an adverse impact on the cooperation, whereas providing assistance too soon would lead to self sufficiency and reduce dependency on India. It is pertinent to mention that providing assets for coastal surveys may satisfy decision makers in SIDS/ small states (for a limited period of time), however it may be inadequate for large coastal states where the scale of assistance would have to be much larger to make significant impact.

6.3.6 **Information Sharing for Update of Charts**. In countries where national agency is not designated/ formed (such as East African countries), port authorities usually have small hydrographic set up rely upon a private entity to monitor and update bathymetric information. These ports or maritime agencies are more inclined to share the data with United Kingdom Hydrographic Office (UKHO) or Hydrographic Offices of erstwhile colonial powers as historically, these Hydrographic Offices (HOs) have been providing coverage of nautical products in their waters (although mostly based on old and imprecise data). In certain instances such as Maldives and Seychelles, the updates to harbor/ approach charts produced by India are not being received on a regular basis. In the absence of any legal framework and established data sharing procedures, even the national authority (if designated) is not able to exercise much control over Port/ maritime agencies, thus leading to undue delay in update of nautical products.

6.3.7 **Streamlining Maritime Safety Information Services (MSIS)**. Collecting and circulating Maritime Safety Information comes under the first phase of IHO Capacity Building strategy. India is the coordinator for NAVAREA VIII and it is incumbent upon coastal states in the region to collect and forward information affecting Maritime safety to NAVAREA VIII coordinator for further dissemination to all mariners. Only few states in the NAVAREA VIII region have necessary organisation and procedures in place to disseminate Maritime Safety Information (MSI) of waters in their jurisdiction. It is important that forums such as bilateral meetings, NIOHC and SAIHC are utilized to assess the capability gaps in providing MSIS. Based on these inputs, there is a need to formulate focused training and technical assistance plan for these countries. Once sharing of MSI is streamlined, it would be easier to pursue Phase 2 and 3 of capacity building through bilateral cooperation.

6.3.8 **<u>Technical Assistance through Hydrographic Teams</u>**. There are many instances wherein, even after receiving significant assistance in terms of training and capacity building, commensurate progress is not achieved by coastal state in hydrographic capability. It is widely accepted that deputing an expert team to overcome the initial hurdles and streamline the equipment and procedures is a much faster way of building capacity. Bangladesh and Mauritius are apt examples of this methodology, wherein Bangladesh received French assistance in 1996 and 2001 under Hydro Bangla Project-1 and Project-2 respectively.[33] Under both the projects, a large number of officers and sailors were trained both in France and in Bangladesh by French surveyors. After those projects, BN shifted from analogue/conventional survey to digital survey and has been making good progress in hydrographic domain. More recently the Indian Hydrographic Training Teams in Mauritius have achieved tremendous success in setting up hydrographic infrastructure and survey capability. Within a short period of five years, a dedicated organization for hydrography is in place, which has been recently rechristened as 'Mauritius Hydrographic Service' in line with its national stature. However it has been observed that there is certain reluctance among coastal states in inviting the experts from another country due to reasons such as budgetary constraints, data security issues and lack of mutual trust. Therefore an alternate mechanism in addition to long term deputation of training teams needs to be formulated for rendering assistance and build trust in the long term in such cases.

6.3.9 **<u>Availability of Nautical Products to Users in Beneficiary States</u>**. Timely availability of updated Indian nautical products for local maritime community, shipping and government agencies of beneficiary countries is one of the main goals of hydrographic cooperation. The time lag involved in placing the request through diplomatic means and subsequent delivery of the products is definitely a setback for marketing Indian charts/ products. Notwithstanding,

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33 http://bnhoc.navy.mil.bd/?page_id=61

such a model may still work in case of SIDS as onward delivery of the charts/ products to users can be coordinated without much effort. Whereas, in case of a large coastal states (with no streamlined coordination mechanism) identifying and procuring the Indian charts for a local user/ mariner is quite difficult.

6.3.10 **Cooperation with Developed HOs**. INHD has been mostly engaged with countries having limited/ no hydrographic capabilities and there has been limited interaction with organizations/ personnel from countries with well-developed hydrographic setup. Over the years, ***IN*** has absorbed numerous procedures, policies and practices through joint exercises, training, delegation visits and interaction with foreign navies Similarly in hydrography too, there is immense scope of sharing best practices and procedures to fine tune the processes being followed by INHD and absorbing emerging technologies.

6.3.11 **Impediments Posed by Existing Procedures**. INHO has been engaging countries in IOR for more than two decades. On many occasions the efforts have not translated to proportionate gains due to excessive procedural delays involved in initiating/ progressing the cooperation. As former colonial powers have considerable influence over countries in Asia and Africa in hydrographic matters (because of historical reasons) consistent efforts are required to wean their influence and establish Indian footprint. Additionally, the countries which engage in hydrographic cooperation with India not only depend on Indian surveys and charts but on the institutional support in overall development of hydrographic and maritime safety services. In many cases, the procedural delays have resulted in significant loss in terms of opportunity, resources and efforts. For e.g. revival of UKHO's influence in Kenya, Seychelles and Mozambique after steady cooperation with India, non-participation of Indian delegation at 14th meeting of SAIHC during which India was to be formally accepted as associate member and inconsistent participation of Indian members at IHO bodies/ working groups (thus leading to permanent loss of representation at such forums) does not augur well for India's standing at international level. Strengthening and expanding hydrographic cooperation in future would require enhanced flexibility of operations for INHO in terms of interacting with Indian missions and relevant national hydrographic authorities abroad, negotiating MoUs, planning delegation/ ship visits and deciding upon quantum of assistance in terms of hydrographic effort, training and assets.

6.4 **<u>Bridging Capacity Gap to Support FC Initiatives</u>**. Engaging in Hydrographic cooperation with littoral states offers immense benefits for India. The cooperation is likely to intensify further in the coming years. Sustaining the higher level of interaction with other countries and meeting their survey, training, capacity building and nautical charting requirements would also entail expanding own capacity in every sphere. Following points are germane in this respect:-

6.4.1 **<u>Ageing Survey Platforms</u>**. A majority of IN hydrographic ships are approaching the end of their service life. At present, only four ships (out of which two are MBES fitted) are in reasonably good material state and suitable for foreign deployment. Taking into account their maintenance cycle, only 2-3 (out of four) are expected to be available for foreign deployments during a survey season. It was initially envisaged that five percent of the total survey effort in a year would be dedicated to foreign surveys (approximately 70 days), whereas because of ever increasing requirement for Indian assistance, generally 100-150 ship days are being dedicated for foreign surveys for the last few years. Therefore to support the envisaged FC initiatives, the capacity needs to be commensurate. Replacement of ageing ships in next 3-4 years and subsequent induction of five ocean-going helicopter capable ships as per Maritime Capability Perspective Plan (MCPP) 2012-2027 is critical to sustain and expand international cooperation.

6.4.2 **<u>Training Facilities at NIH</u>**. The number of training slots at NIH, Goa needs to be increased along with associated administrative support in terms of equipment, manpower, accommodation, and classrooms to cater requirements of International training.. Hydrographic Training for Trainer (TFT) needs to be pursued for instructors posted at NIH. At present Cat 'A'/'B' course in nautical cartography is not being offered by INHD, whereas the demand for cartographic courses in on the rise. To start with few service/ civilian officers could be deputed for Cat 'A' and Cat 'B' nautical cartography course in UK and subsequently structured training courses can be commenced at NIH for Indian and foreign trainees.

6.4.3 **Chart Production**. Publishing and maintenance of increased number of charts would require capacity enhancement of chart branch. Sections dedicated to foreign surveys would have to be augmented with additional Hydrographic Production Database (HPD) licenses and requisite manpower. In order to take over the charting responsibility of areas in IOR from European HOs, the existing data acceptance procedures (for foreign waters) are recommended to be revisited with decentralized structure of decision making.

6.4.4 **Adopting Emerging Technologies**. Technologies such as Laser Bathymetry, Satellite Derived Bathymetry (SDB), Unmanned Survey Vessels (USVs) and Unmanned Aerial Vehicles (UAVs) are concepts which have a promising future and could potentially act as force multipliers for hydrography in Indian as well as foreign waters. For e.g. Laser Bathymetry has immense scope in mapping coastal waters around Indian island territories and littoral states in IOR at a much faster pace without deploying an ocean-going survey platform. Similarly SDB could also be used for faster mapping of largely unsurveyed areas and determining priority areas for detailed acoustic surveys provided the technology is enhanced to meet stringent IHO quality requirements. UAVs are extremely successful in mapping the coastal regions at high resolution and generating ortho-photos. Most of the field work related to coastline delineation can be automated using them. USVs have been successfully proved in inland waters in many parts of the world. The technology has many applications in India too if successfully proved under local conditions.

6.5 Being one of the advanced hydrographic service in the region it is imperative that the Indian Hydrographic Service look beyond the present horizon and harness the trends that are emerging and at a very nascent stage. It will be beneficial for both the service and the nation if we move proactively as a maritime nation and ensure that we don’t lack behind in this aspect and move shoulder to shoulder with the other hydrographically advanced nations. Few of the emerging trends which are at very nascent stage are discussed below:-

6.5.1 **Extending Hydrographic Data beyond Charting**. Hydrographic data can be collected once and used many times. Technological advances in processing this data give a better understanding of our environment, which in turn opens new opportunities and directly supports the so-called blue economy. This is a key piece of information, which is frequently missed by policy makers because very few people know or understand what hydrography is and because it was defined by one result for centuries: the chart. This chart, essential for mariners, only becomes relevant for the rest of the world when something bad happens. But if hydrographic data is used in a broader context such as in oceanography, pollution control, offshore energy and any other maritime area it becomes essential for geospatial analysis, i.e. for GIS use. All the data collected during hydrographic surveys, such as sound velocity profiles, ADCP casts, sediment classification, tides, currents, turbidity, and shorelines are very valuable beyond "sounding corrections" and beyond charts. When used in GIS the "collecting once and using many times" becomes real. There is no denying that Hydrographic data is a critical asset for any activity at sea and in coastal areas, with bathymetry being perhaps the most relevant contribution by hydrography to the marine community; hydrographic data feeds nautical charts and every single maritime project. It becomes a primary data source for a Marine GIS. In the end, hydrographic data contributes to the development of ocean and coastal economic activities, and geographic information systems provide the means to extract the required value.

6.5.2 **Hydrographic Data and Spatial Data Infrastructures (SDI)**. An SDI provides a framework for organising geographic data, metadata, tools and users with rules, relationships and standards. A Marine SDI is not meant to be separated from other SDIs but is complementary in the coastal zone and oceans. Hydrographic data is the basis of Marine SDIs. Esri supports many SDIs, such as INSPIRE in the EU; a software portal called ArcGIS for INSPIRE supports compliance, data sharing and discovery of harmonised geospatial data across Europe. All SDIs have similar goals: contributions and data sharing; and have a common denominator: Cloud Computing and Big Data.

(a) **Cloud Computing**. There are different types of cloud computing service models: “Software as a Service” (SaaS), where the end-user applications are delivered as a service rather than installing software on-premises; “Platform as a Service” (PaaS), where an application platform or middleware is delivered as a service on which developers can build and deploy custom applications; and “Infrastructure as a Service” (IaaS), where computing, storage or other IT infrastructure is delivered as a service rather than as a dedicated capability. ArcGIS Online is a good example of all three. There are public, private or combined (hybrid) clouds with different benefits from each approach.

(b) **Big Data**. Working with Big Data is challenging because of the volume of the data, the velocity of the data and the variety of the data. The amount of data being collected nowadays is massive. With the growing social media, multimedia data will continue to grow exponentially in the foreseeable future. In Hydrography, with the use of Multibeam Lidar and Satellite systems for bathymetric data collection in combination with new and more powerful data collection and post-processing software, Big (Hydrographic) Data is a reality, and the challenge comes when the user tries to analyse those huge datasets that can jeopardise productivity. Big Data, when used to its full extent, generates value by way of savings in production and diversifying data use. Users can analyse big data using ArcGIS tools and spatially query billions of records in a matter of minutes instead of hours, simply by taking the software to the data rather than the data to the software, unlocking significant value by making information transparent and usable at a higher rate, connecting and combining hydrographic data with other types of datasets and reaching many more users.

6.5.3 **Consumers vs. Enterprise Mapping**. We can identify two types of users in the geospatial community. Firstly, people that only access this data for awareness, decision making and planning purposes, called ‘consumers’ of geospatial data. These users are generally positioned at managerial and executive levels in their organisations and are not experts in GIS. Secondly, there is a group of people that collect and analyse data and create products and services, i.e. basically the map and chart makers and GIS professionals. The latter group is always in direct contact with the needs of the 'consumers' (their customers) and provides products and tools to attend those needs. Both groups make use of Cloud Computing and Big Data at different levels.

6.5.4 **The Challenge: Data Dissemination**. **In order to** exploit hydrography efficiently beyond charting we need to organise hydrographic data in a logical way, i.e. in a database or several databases, which can be access in different ways by users, for production (like nautical charts) to consumption for analysis, planning and decision making. This is where a national hydrographic office and other hydrographic data producers become key players in an SDI context, building from and contributing to the Marine SDI part (together with other marine entities). Through an SDI, geo-spatial data can be organised, managed and shared among agencies and will finally provide people with useful and authoritative data and products for their day-to-day lives. But making this data available to people can be challenging. With technology such as ArcGIS Server, from which people can deliver hydrographic data as a service, having complete control and centralised management over how and where this data is delivered, deploying it behind an organisation's firewall or a private instance in a public cloud; or ArcGIS Online from which charts, maps and information can be accessed practically from anywhere, anytime and consumed with free apps from smartphones and tablets. These are cutting edge technologies that can make these processes very efficient. And it does not have to be limited to a one-way dissemination; feedback from users is also a very important part of the cycle. Some people may identify this feedback as the so-called 'crowdsourcing', which would warrant a separate discussion.

6.5.5. **Land and Sea are Part of the Same Ecosystem**. The marine environment is not independent of land. Coastal or littoral areas are transition zones between land and sea, where many people live and where very important economic activities take place. So, why separate land from sea? There is continuity after the zero depth beyond the shoreline, and these adjacent areas cannot be ignored and should be part of the hydrographic data coverage. Tides and currents not only affect navigation, they also have an impact on the littoral areas; a Digital Elevation Model (DEM) is not truncated at the zero depth, in simple terms it is the prolongation of the seabed above water; and the slope and morphology combined with other parameters determine how this ecosystem works and how it can be developed. Hydrographic data is vital for that determination.

6.5.6 **Hydrographic Standards**. Perhaps one big difference when compared to other marine sciences, is that Hydrography has several standards that form the basis for its collection, analysis and production. The new IHO S-100 Universal Hydrographic Data Model, based on the ISO 19000 series and TC211 for international geo-standards, enables Hydrographers to think GIS; not only to produce charts, but to develop new Geographic Markup Language (GML) schemas to utilise hydrographic data in different ways, from the traditional safety of navigation such as the S-101 next generation of ENCs to the new bathymetry raster standard S-102, or Ice Coverage and any other GML product specification based on S-100. Other industries, such as the Oil & Gas, have developed a geospatial model called the Seabed Survey Data Model, based on the Esri Geodatabase model that may someday become an S-100 based GML. All these are steps towards geospatial data production from hydrographic data, not only charts.

CHAPTER 7

EMPLOYMENT OF HYDROGRAPHY FOR ENHANCED FOOTHOLD

7.1 **Scope of Hydrographic Cooperation in IOR and beyond**. Indian National Hydrographic Office (INHO) is one of the leading hydrographic organizations and well placed to make a significant contribution to bridge the capacity gap which exists in the world, particularly in Africa and Indian Ocean Region (IOR). The department has already taken a number of initiatives in promoting hydrographic cooperation with long term strategic gains in mind. It will be the endeavour to examine the existing Foreign Cooperation initiatives in hydrography in this chapter and recommend way ahead for enhancing Indian footprint at international level to foster national gains.

7.2 Hydrography is a completely benign activity and presents an array of benefits for a coastal state. It is a tool for development which has a universal appeal cutting across geographical boundaries. It enables prolonged presence and close contact with the maritime agencies as well as civic authorities and general populace during the course of surveys. The International Hydrographic Organization (IHO) promotes the cooperation in hydrographic matters among member states. The countries having adequate infrastructure and resources are encouraged to assist those requiring hydrographic support, because lack of hydrographic data affects international shipping and maritime safety as a whole and not just the particular coastal state.[34] At the regional level, the need to improve maritime safety has been identified as one of the topmost priority by Indian Ocean Rim Association (IORA) action plan 2017-21 for implementing Jakarta concord signed by member states in March 2017.[35] A combination of these factors presents an opportunity for India & Indian Navy to make inroads in this domain as only a handful of countries in Asia and Africa have fully

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[34] IHO Publication M-2, The Need for National Hydrographic Services-Ver 3.06-Dec 2016

[35] IOR/COM/20ANNIV/17/DOC3.1-IORA ACTION PLAN 2017-2021

evolved hydrographic services encompassing field surveys, nautical charting, Maritime Safety Information Services (MSIS) and training. The possession of immense underwater data which enabled erstwhile colonial powers to have complete control of the seas is common knowledge. The importance of gathering/ obtaining this data and maintaining database needs no further emphasis. The Indian Naval Hydrographic Department is already a front runner in the region and capable of being a major player beyond IOR. The cooperation with coastal states beyond IOR can be divided into following two categories:-

7.2.1 **Countries with well Developed Hydrographic Infrastructure**. UK, France, Japan, South Korea, United States, Russia, European HOs fall under this category. The cooperation with such countries may interalia include:-

(a) Establishing mechanisms for sharing data of the regions of Indian interest such as IOR, Malacca Straits, South China Sea, Antarctica for publishing/ updating Indian/ INT charts or attaining strategic advantage in the ***IN*** areas of operation/ interest.

(b) Reciprocal ship visits, joint training surveys and sharing of best practices in terms of ENC Production, Laser Bathymetry, AUV, satellite bathymetry, next generation hydrographic platforms and other emerging technologies through workshops and delegation visits.

(c) Exchange of trainees for hydrographic and cartographic courses.

(d) Free exchange of Charts/ ENCs for IN/RAN use.

(e) Joint collection of hydrographic and oceanographic data outside Indian EEZ in the areas of mutual interest.

(f) Cooperation at IHO level on matters of mutual interest.

7.2.2 **Developing States requiring Hydrographic Assistance**. There are many states beyond IOR, especially in South East Asia, West Africa and SIDS in Pacific Ocean where hydrography continues to be in neglected state and external assistance in capacity building is much required. INHD has established links with many such states such as Nigeria, Fiji, Micronesia, Cameroon, Phillipines etc, wherein the personnel have undergone training at NIH. The conventional approach of direct assistance through hydrographic surveys would entail committing substantial hydrographic effort because of excessive transit time involved in deploying ships to Western Africa or beyond South East Asia. The IN Survey ships are high endurance platforms and can be deployed beyond IOR, if the same is necessitated because of national interest. More countries may be added in the list ads and when we bolster our capabilities and induct next generation survey platforms. The recommended scope of cooperation with countries beyond IOR is as follows:-

(a) Training slots under ITEC scheme for courses at NIH.

(b) Technical visits in coordination with IHO and interaction with decision makers for long term commitment in promoting hydrography.

(c) Assist in setting up hydrographic office by deploying INHTTs.

(d) Providing cartographic assistance for publishing nautical products of the country through bilateral arrangement.

(e) Assistance in terms of hydrographic assets in certain cases.

(f) Assistance towards delineation of maritime boundaries and submission of claims through table top studies.

7.1.3 Given the considerable hydrographic assets and expertise of the Indian Naval Hydrographic Department, the Training, Foreign Cooperation and participation in International Forum can be used as potent tools for exhibiting the global reach and presence of Indian Navy. Some of these areas are as follows:-

(a) Joint Hydrographic surveys can be undertaken by deploying I.N survey ship on mutually agreeable terms. The data collected can be used for printing of new Navigational Charts or updating existing charts. Joint surveys also provide on job training (OJT) for Hydrographers on the complete process of planning and execution of hydrographic surveys, data logging, processing and completion of charts.

(b) Offer Technical assistance & consultancy services for setting up of Hydrographic Office and other facilities.

(c) Training of Hydrographers (including afloat attachment in the case of officers) to IHO Cat 'A' and Cat 'B' standards at National Institute of Hydrography, Goa.

(d) Assist in production of Electronic Navigational Charts (ENC) in S-57 format as laid down by IHO.

(e) Survey assistance for Continental Shelf Claims under UNCLOS.

(f) Assist in conduct of CZM studies which involves field surveys and preparation of Coastal Zone maps. The Naval Hydrographic Department has done similar projects for five Indian states till date.

(g) OSDs of Survey ships to the neighboring countries and countries of Indian Ocean region for exhibiting our Hydrographic capacity as well as our reach.

(h) Form Command wise Rapid Survey Teams for quicker responses in future to deal with natural calamities.

(j) In order to have a meaningful outcome and better say in the International forum, appoint permanent members in the committees and sub committees of IHO/IMO.

(k) Foster closer ties with Russia in the field of Hydrography for bolstering Indo - Russia chart programme in Antarctica.

(l) Government to Government chart selling agents in IOR can be appointed.

(m) The INHD should organize a seminar once in two years with adequate departmental representation on the line of WMTC, Def-Expo, IONS and INMAX to name a few.

(n) Active participation in the IOR choke points projects like Marine Electronic Highway in Strait of Madagaskar and Malacca Strait.

(p) Undertake Joint Surveys/embed personnel with advanced survey organization like UKHO, US & Australia for continuous upgradation.

(q) Participation of personnel from INHD in upgraded QA/QC courses under aegis of IHO/IHB.

(r) Leasing of Survey crafts on contractual basis with prune down staff & support from IN to IOR countries.

7.1.4 The areas of cooperation with countries of IOR could also include:-

(a) Conduct of hydrographic, oceanographic and Coastal Zone Regulation surveys.

(b) Training in Hydrography and cartography.

(c) Setting up of hydrographic infrastructure and Hydrographic Offices.

(d) Production of Electronic Navigational Charts (ENCs) as per IMO/IHO approved formats/specifications.

(e) EEZ/continental shelf surveys for delineation of maritime areas under the provisions of United Nations Conventions on the Laws of the Sea (UNCLOS).

(f) Training and organizing the maritime safety organisation and structure.

7.1.5 The cooperative engagements executed and contemplated have far reaching consequences for the Indian Naval Hydrographic Department. They have the potential to exponentially advance the reach and presence of the Indian Navy. Some of the spin-offs accruing from hydrographic initiatives are:-

(a) Use of hydrography as an effective tool of naval diplomacy.

(b) Embedding ourselves in regions, where the Indian presence is not visible, under a very benign cause. This continued presence can translate into obvious gains for the IN.

(c) By assisting developing countries of the region in their hydrographic surveys and training, India stands to generate regional goodwill as has been done in the past.

(d) Projection of India’s advanced capabilities in the field of hydrography thereby boosting the exchange of hydrographic / cartographic data, products and services with other countries in line with the present global economic trends.

(e) As part of hydrographic capacity building, India can play a significant role in the evolution of hydrography in the region, the spin-offs of which are quite obvious.

(f) Promotion and projection of Indian hydrographic training facilities and infrastructure thereby ensuring the leading status of the country in the field of hydrography.

CHAPTER 8

SUMMARY OF RECOMMENDATIONS

8.1 The traditional boundaries of hydrography and its related fields like geophysics, geo-technical and other ocean sciences have become fuzzier. Vessels now draw deeper draughts and marine customer needs have widened. This has led to increase in the information content of charts and on the accuracy. The advent of ECDIS, a quantum jump in technology, has now created the need for providing complete range of hydrographic products in digital form.

8.2 Hydrographic applications in marine coastal development and environmental preservation have become a growth area the world over. The ongoing economic liberation has seen mushrooming of minor ports resulting in an increase in the survey requirements be it for navigation safety, defence or project related. Hydrography today has come to occupy an extremely prominent place in infrastructure development, foreign cooperation, defence operations and a host of other related fields encompassing a wide range of disciplines at sea. In fact the definition of hydrography has evolved over the years and today it reflects a wide swath of activities which hitherto had been considered outside the ambit of hydrography.

8.3 **Way Ahead for Strengthening Cooperation in IOR and Beyond**. A maritime accident/incident would not be limited by any man made boundaries but would affect all in vicinity. Notwithstanding these ongoing projects, an urgent need exists to augment the hydrographic capabilities in the Indian Ocean region. This also provides a window of opportunity for promoting International Hydrographic Cooperation within the IOR with attendant significant benefits in terms of availability of vital ocean data for our areas of interest within this region, increased naval presence in the region, accrual of substantial financial benefits from rendition of hydrographic services, data and products not to mention the intangible benefits of improved maritime safety in our region. The most tangible gain would invariably be the increased strategic reach of our country through the Indian Navy.

8.4 As highlighted earlier, a great potential exists for promotion of hydrographic cooperation with countries of the Indian Ocean Littoral Region in line with the existing IHO policies, especially in view of the rudimentary hydrographic capabilities currently existing with the countries of this region. However, the desired results on this aspect can only be achieved through a vigorous, continuous and continual pursual of hydrographic cooperation by the Indian Missions abroad, especially those in the Indian Ocean rim. Assistance of Government and all other stakeholders would be required to take up this issue with Ministry of External Affairs so as to make the promotion of hydrographic cooperation as one of the missionary objectives of our missions abroad.

8.5 The hydrographic cooperative engagements executed and contemplated so far have far reaching consequences for the India. They have the potential to exponentially advance the reach and presence of the Indian Navy. Some of the spin-offs accruing from hydrographic initiatives are:-

(a) Use of hydrography as an effective tool of naval diplomacy.

(b) Embedding ourselves in regions, where the Indian presence is not visible, under a very benign cause. This continued presence can translate into strategic reach for the IN.

(c) By assisting developing countries of the region in their hydrographic surveys and training, India stands to generate regional goodwill as has been done in the past.

(d) Projection of India’s advanced capabilities in the field of hydrography thereby boosting the exchange of hydrographic / cartographic data, products and services with other countries in line with the present global economic trends.

(e) As part of hydrographic capacity building, India can play a significant role in the evolution of hydrography in the region, the spin-offs of which are quite obvious.

(f) Promotion and projection of Indian hydrographic training facilities and infrastructure thereby ensuring the leading status of the country in the field of hydrography.

8.6 The present hydrographic capacity and requirements of coastal states have been analysed based on technical visits by IHO, national reports submitted at Regional Hydrographic Commission (RHC) meetings and NHO's interaction with respective countries. The impediments posed by factors as listed in Para 13 have also been considered. The way ahead to further strengthen the hydrographic cooperation for countries in IOR and beyond has already been discussed in chapter 5. A summary of the foreign cooperation initiatives so far by Indian Hydrographic Department has also been mentioned in Chapter 5.

8.7 **Enhancing Indian Footprint at IHO**. Indian contribution at IHO is well documented and highly appreciated internationally. Being a major maritime nation, it is necessary that India continues to be part of decision making process at IHO to ensure that Indian interests are safeguarded. Following measures are recommended for enhancing Indian footprint at IHO:-

(a) To secure continuous representation in IHO council under the criterion of 'Hydrographic Interest'. Presently under this criterion 10 seats are allocated on the basis of **National Flag Tonnage (NFT)** (which is not in India's favour) and remaining 20 are divided between various RHCs and decided through election within respective RHCs. The definition of 'Hydrographic Interest' is already under deliberation and the issue would come under consideration at the second IHO assembly in 2020. India needs to seek diplomatic efforts so that additional factors are taken into account to define 'Hydrographic Interest'. Few examples are number of national/ INT charts produced, quantum of hydrographic assets, role in promoting hydrography and training provided to various countries. This would also be in line with IMO's statutes, where in multiple other factors such as trade volumes and special interest in maritime transportation or navigation are taken into account in addition to tonnage.[36]

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[36] http://www.imo.org/en/About/Pages/Structure.aspx

(b) Enhancing Indian contribution to IHO committees and Working Groups (WG). It is necessary that personnel who are members of such committees and WG regularly attend the meetings, and submit comprehensive inputs in response to concerned IHO resolutions/ publications/ letters.

(c) Hosting meetings of IHO committees, sub-committees and Working Groups in India would provide international exposure to a large number of Indian officers. In the long term, such efforts would lead to thorough understanding of these forums and increased representation of Indian officers.

(d) Maintaining direct and continuous contact with well established Hydrographic Offices would further provide an opportunity to cooperate on issues of mutual interest at IHO.

(e) In order to have significant Indian influence at IHO, it is necessary that elections of Directors and Secretary General of IHO are also contested by Indian representatives. Our significant standing in the region could be utilized by formally (and informally) seeking support of the countries (who have benefitted from Hydrographic cooperation with India) and canvassing at international level through MEA.

8.8 **Recommendations**. The recommendations to further strengthen and expand the hydrographic cooperation are as follows:-

(a) Prioritisation of countries for hydrographic cooperation in consultation with ***IN*** and **MEA**. Formulation of scale and scope of cooperation with each country which should be revised after certain duration based on the progress.

(b) For sustainable cooperation, it is essential that hydrography becomes part of the '**Whole Government Approach**' of development, wherein other tangible benefits of Blue Economy follow hydrographic surveys/ charting. This would require higher level of commitment by Government of India and needs to be steered at the level of MEA through local High Commission/ Embassy.

(c) The ministry/ department responsible for various financial aspects of cooperation, such as rendering of services, setting up infrastructure, gifting of assets or deputing training teams abroad may be identified. This would ensure that there are no delays in delivery at any stage resulting in strong partnership in the long term.

(d) For long term success of bilateral cooperation, it is necessary that beneficiary state be strongly advised during preliminary meetings to designate a suitable national agency (capable of dealing with hydrography). Subsequently, strong links be established with the designated national agency for furthering FC initiatives.

(e) Active coordination with Port authorities/ Maritime Agencies in addition to (or in the absence of) designated national authority for data sharing for updating charts published by INHD. UKHO has a policy of supplying free copies of updated charts to the ports that forward data/ updates.[37] This encourages port authorities to cooperate more closely with UKHO. It is recommended that the policy be adopted for port authorities of the foreign harbours which have been covered by IN surveys.

(f) Formulating a calibrated plan for assistance in terms of hydrographic assets and capacity building while balancing aspirations of the beneficiary state (for indigenous capacity) and long term dependency on India.

(g) Diversification of product portfolio of INHO to include boat charts, derived products, mobile applications etc. for tourism and fishing applications so that benefits hydrography are directly felt by wider population.

(h) Adopting alternate methods for embedding the personnel for hydrographic assistance. Short duration deputations ranging from 15 days to 06 months annually/ biennially for monitoring/ course correction/ further

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37 https://www.admiralty.co.uk/AdmiraltyDownloadMedia/UKHO/UKHO_Harbour_Masters_Guide.pdf

expansion would turn out to be more acceptable to coastal states, especially those on shoe string budget. Additionally, the cost of deputation of teams could be borne partly by India, thereby reducing the burden on beneficiary country.

(j) Creating online portal for placing demands for nautical products alongwith payment gateway to reduce the time lag involved in procuring Indian charts through diplomatic/ official means by users in another country. The distribution and dispatch could be offloaded to a reliable chart agent based in India/ overseas.

(k) Indian participation/ contribution to IHO publications, working groups and committees to be systematically enhanced with eventual aim of shaping decisions at international forums in accordance with Indian interests.

(l) Improving interaction with advanced hydrographic offices by deputing personnel for training courses offered by IHO or other HOs, reciprocal delegation/ ship visits for sharing the best practices in surveying techniques and emerging technologies, joint training surveys and hosting NIOHC/ IHO sponsored training courses in India (for maximum participation of Indian personnel).

(m) Capacity gaps identified at Para 16 be pursued on priority and resolved expeditiously.

8.9 **Conclusion**. The requirements of hydrographic surveys in littoral states are on the rise because of increased shipping activity and focus on sectors related to Blue Economy. However, many littoral states do not have adequate hydrographic capabilities to support these emerging requirements. As a result there is immense scope for collaboration between countries in terms of mapping ocean areas, production of nautical products and capacity building.

8.10 India has always been at the forefront in supporting regional mapping and capacity building efforts. Because of well-equipped hydrographic platforms, infrastructure and training facilities, cooperation with INHD is much sought after by littoral states. The benign nature of hydrography and resulting spin offs in terms of economic gains have resulted in hydrographic cooperation becoming a preferred tool for naval diplomacy. Equipping INHD with next generation survey platforms, adopting emerging technologies and re-aligning the present approach towards Foreign Cooperation would be the key factors for success in the years to come. India being major maritime state with a leading Hydrographic Office, it is necessary that Indian interests are preserved through larger footprint in hydrographic domain by augmenting FC initiatives, increased participation at IHO and its subsidiary bodies.

8.11 With the Indian Ocean pitch forked into the humdrum of maritime affairs in the last few decades, various factors of growth have benefited the marine community in this region. As with India all the countries are looking towards reaping the benefits of the shrinking distances. This has brought about its own share of requirements and necessities. The increasing maritime traffic has not only resulted in the crowding and reduced maneuvering space, but also has provided a soft target for unlawful and terrorist activities. On the other hand, due to a largely landward looking mindset coupled with severely restricted financial resources has resulted to limited or no hydrographic wherewithal this region. These countries continue to view the oceans as an enigma. India to its credit has an extremely credible Hydrographic service which has ensured high standards of marine safety requirements in keeping with international standards. The Indian Naval Hydrographic department has time and again proven its credential not only in near shore environment but also beyond our own sphere of influences. This singular instrument in more than one way has ensured that we are counted amongst the forerunners in this sphere. India has contributing considerably and has provided assistance in kind to countries in this field which has steadily seen the number of stakeholders increase. The requirement is naturally bound to increase as the spins offs are offering dividends to the recipient countries. With much more to contribute, India stands at a vantage position and at a turning point of time to leapfrog into international hydrographic cooperation in a big way and be a tool towards the improved foreign diplomacy.

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Annexure to Chapter 6
(Refer Para 6.3.1)

MATRIX FOR FOREIGN COOPERATION

HYDRO ACTIVITY / COUNTRIES	HYDRO TRAINING IN INDIA	JOINT SURVEYS	TRAINING ON ENC PRODUCTION	PRODUCTION OF CHARTS/ DERIVED PRODUCTS	HANDING OVER HYDRO ASSETS	FREE EXCHANGE OF CHARTS/ SHARING DATA FOR INT CHARTS	RECIPROCAL SHIP VISITS	EXCHANGE OF PERSONNEL	SHARING MSI	DEPUTING TRAINING TEAM
MAURITIUS	✓✓	✓✓	×✓	✓✓	✓✓	⊙	⊙	⊙	✓✚	✓✓
SEYCHELLES	✓✓	✓✓	⊙	✓✓	×✓	⊙	⊙	⊙	✓✚	×✓
MYANMAR	✓✓	✓✓	✓✓	✓✓	⊙	×✓	⊙	⊙	✓✓	×✓
MALDIVES	✓✓	✓✓	⊙	✓✓	×✓	⊙	⊙	⊙	×✓	×✓
SRI LANKA	✓✓	✓✓	✓✓	✓✓	×✓	⊙	⊙	⊙	✓✚	×✓
KENYA	✓✓	✓✓	⊙	✓✓	×✓	⊙	⊙	⊙	×✓	×✓
TANZANIA	✓✓	✓✓	×✓	✓✓	×✓	⊙	⊙	⊙	✓✚	×✓
INDONESIA	✓✓	✓✓	×✓	⊙	⊙	×✓	×✓	×✓	✓✓	⊙
OMAN	✓✓	✓✓	×✓	⊙	⊙	×✓	×✓	⊙	⊙	⊙
THAILAND	✓✓	×✓	×✓	⊙	⊙	×✓	⊙	⊙	⊙	⊙
MOZAMBIQUE	✓✓	✓	×✓	✓	⊙	⊙	⊙	⊙	⊙	⊙
BANGLADESH	✓✓	×✓	×✓	⊙	⊙	×✓	×✓	⊙	✓✓	⊙
SOUTH AFRICA	✓✓	⊙	⊙	⊙	⊙	×✓	×✓	×✓	⊙	⊙
UAE	×✓	⊙	⊙	⊙	⊙	×✓	×✓	×✓	⊙	⊙
IRAN	×✓	⊙	×✓	⊙	⊙	×✓	×✓	×✓	⊙	⊙
AUSTRALIA	×✓	⊙	⊙	⊙	⊙	×✓	×✓	×✓	⊙	⊙

NIGERIA	✓✓	⊙	×✓	⊙	⊙	×✓	⊙	⊙	⊙	×✓
MALAYSIA	✓✓	⊙	×✓	⊙	⊙	×✓	⊙	×✓	⊙	⊙
UNITED KINGDOM	⊙	⊙	×✓	⊙	⊙	×✓	×✓	×✓	⊙	⊙
DEVELOPED HOs BEYOND IOR	⊙	⊙	⊙	⊙	⊙	×✓	×✓	×✓	⊙	⊙
REMAINING COUNTRIES BEYOND IOR	✓✓	⊙	✓✓	×✓	×✓ CASE TO CASE BASIS	⊙	⊙	⊙	⊙	×✓

SYMBOL	MEANING	SYMBOL	MEANING	SYMBOL	MEANING
✓	COMMENCED	✓✓	COMMENCED & TO BE CONTINUED	✓✚	COMMENCED, TO BE IMPROVED
×✓	NOT COMMENCED, TO BE INITIATED	⊙	NOT ENVISAGED	--	