HYDROGRAPHIC SERVICES FOR THREE-DIMENSIONAL BANGLADESH NAVY

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Sun Tzu's famous adage on terrain *is relevant for the role of hydrography:*
"Know the ground; your victory will then be total[1]".

Introduction

1. The value of environmental information for planning and executing naval operations has been recognized by developed Navies for decades. The 21st century's battlefield has evolved dramatically. Remaining at the forefront of technological development, global navies have adopted network centric warfare long before their army and airforce counterparts. At the heart of 21st century naval warfare, the knowledge of where and how remain important. Of the different branches of the armed services, navies have been the most susceptible to environmental conditions due to their operational environment. The different factors associated with operations in maritime environments have made environmental data forecasting important especially to naval operations. In today's naval engagements, accurate depiction and forecasting of environmental conditions can be used to provide a significant advantage over an adversary. Hydrographic survey started with the use of hand lead and line along with the age of sails. Today in modern hydrography, surveyors are using state of the art technologies and equipment. Even with the advent of technology and significant increment in global shipping, less than 10% of the ocean floor remains fully surveyed. Mankind have ventured into other planets but knowledge of the oceans remains unexplored. Throughout the world, navies are one of the most prominent users of hydrographic products. Navies of the advanced nations have put significant efforts to develop and expand their hydrographic and oceanographic services. Bangladesh is no exception.

2. Military hydrographic demands require greater accuracy than those required for surface navigation and specific operations. A naval hydrographic capability critically enables military operations by improving oceanography, rapid assessment of the environment for operations, and to fulfil the unique requirements demand by submarine littoral operations. A 21st century modern navy is a three-dimensional force. The warfare takes place on water, above and under and thus geographic, oceanographic and metrological conditions affect the conduct of Maritime operations at sea. The spectrum of maritime operation ranges from deep water (Blue Water) to the shallow water of Littoral Regions (Brown Water)[2]. To solidify war preparedness and to use the ocean environment at maximum to gain own advantage, hydrography & oceanography plays a crucial role. **Bangladesh Navy Hydrographic Services (BNHS)** has traversed quite a long way and evolved into a modern service. **BNHS** encompasses all the activities of **Hydrography,**

[1] Sun Tzu (Samuel B. Griffith translation), The Art of War (Oxford, UK: Oxford Press, 1963), 129.
[2] Maritime Doctrine of Bangladesh, P 22

Oceanography and Meteorology. The surge of Bangladesh Navy (BN) expansion in last decades is remarkable and the government is very supportive to develop a credible fleet with robust and dynamic support structures in the frame work under 'Forces Goals 2030' Initiative.

3. In this paper, endeavour will be made to quantify the operational support required for any modern three-dimensional navy from its organic hydrographic/oceanographic services based on naval warfare history and current doctrines in use by modern navies. Then an assessment of BN's current capability of hydrographic services and its impact will be discussed. From this discussion, a comparison will be made to ascertain the areas with improvement need. Finally, a comprehensive expansion outline of hydrographic services required to meet the operational need of a three dimensional 21st century navy will be penned down.

Aim

The aim of this paper is to explore the scope and potential of development of hydrographic services of Bangladesh Navy to provide required operational support consistent with the capabilities of a 21st century three-dimensional Navy.

Requirement of Hydrographic, Oceanographic & Meteorological Data for Naval Operations

Importance to Command Level

A Navy's operational impact greatly relies on how much its fleet can manoeuvre in operational area. A CTF must decide what sort of assets he must deploy against the enemy force but the decision is always limited on basic factor of navigability. Navigability is assessed by using common maritime products i.e. Charts and NPs, which are compiled using data collected through hydrographic[3] activities. Hydrographic, Oceanographic and Meteorological information offer superiority of command over the adversaries. As practiced in the Modern Navy's, Commander's Critical Information Requirement (CCIR) which is defined as an information requirement critical to the "decision-making process that affect successful mission accomplishment"[4]. Geospatial intelligence information furnished by Hydrographic office creates the base for Force Common Operating Picture (FCOP). This enables naval commanders to make informed decisions. Hydrography today is crucially relevant as an acute contributor to operational decision making.

[3] Definition of Hydrography by IHO: Hydrography is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection.

[4] NWP 3-02/MCWP 3-31.5, Ship to Shore Movement, 1-3.

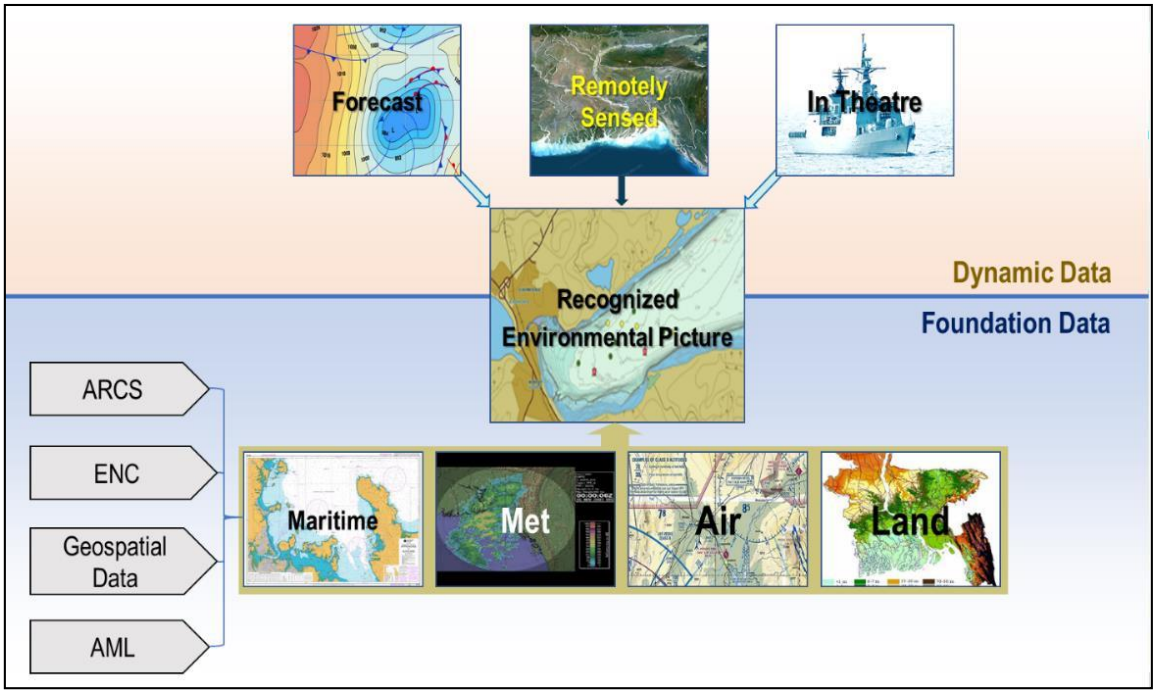


Figure 1: Example of a Joint Force Common Operating Picture Layers[5]

Operational Planning

Hydrography data is shown to be crucial for planning and decision making in the modern joint military environment and must be maintained as a key component of a capable naval force. In the Western Navies, an officer with a Military Hydrographer background is involved in the fundamental planning steps of an operation in order to provide an **accurate and timely assessment of hydrographic conditions to base further operational planning**[6].

Use of Weapons and Sensors

The weapons utilized by today's modern Navy are diverse and very sensible. Although there are many different types of ordnance, groups of them share similarities that will highlight how weather affects their deployment. The sensing systems that guide ordinance to their target include: infrared guided weapons, acoustically guided weapons, GPS guided weapons etc. These systems are highly depended on environmental factors. A summary of guidance systems and their environmental limitation factors are shown in the table below:

[5] NATO AML Handbook, Ed-4, p-21
[6] US Military Joint Publication 5-0, Joint Operations for Planning (Chairman, Joint Chiefs of Staff, December 2006), III-27.

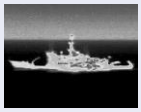
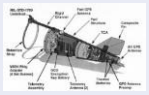
PGM Systems		Environmental Limitations
	Electro Optical	Clouds, Haze, Sun Angle, Precipitation, Light Levels
	Infrared	Clouds, Fog, Haze, Aerosols, Sun Angle, Precipitation, Light Levels
	Laser	Clouds, haze, Absolute Humidity
	GPS	Wind Director & Speed, Turbulence
	Microwave (Radar)	Clouds (moisture-laden), Precipitation

Table 1: Environmental Variables Impacting Precision Guided Munitions[7]

Above Water Warfare

Surface Warfare. To effectively employ one's force or deter other, the knowledge of where is supplanted by navigational charts, be it paper of electronic. In the late 20th century, electronic charts provide intelligent systems with detailed information of seabed topography and other features. Needless to say, the Modern Navy's took it many steps further by adding more and more layers of information suitable for tactical use. Thus, Additional Military Layer (AML) was born. In addition to that, naval surface forces are constant users of meteorological data in relation to planning and movement. Physical oceanographic data is used for surface ships to hunt submarines. Other than that, coastal topography and current information can give an idea where it is best to employ a minefield.

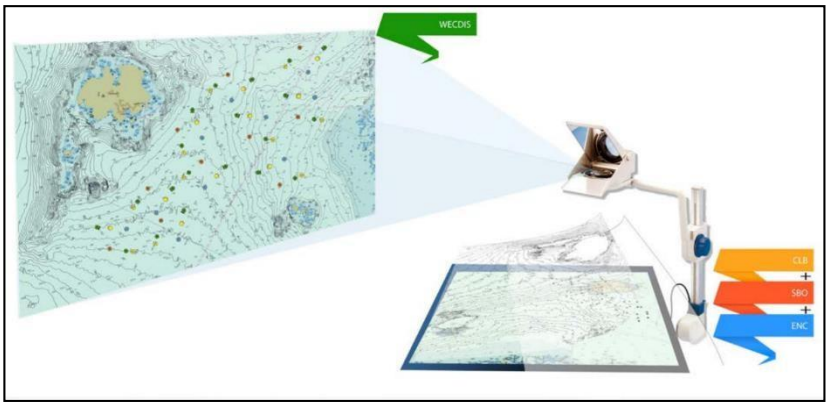


Figure 2: AML- Conceptual representation showing Contour Line Bathymetry, Small Bottom Objects (wrecks) and ENC[8]

[7] Saliba and Peter, Exploiting the weather gap: meteorology and naval operations in the 20th Century (Monterey, California. Naval Postgraduate School, 2002-05), 17.
[8] NATO AML Handbook, https://www.admiralty.co.uk/AdmiraltyDownloadMedia/AML/AML%20Handbook.pdf

Naval Aviation. Weather is an increasingly important factor in naval operations, especially for aviation. Historical analysis provides examples of weather and its influence over military operations. Military significance of weather has its roots in changing venues of naval operations, changes in forecasting technologies and changes in military weapons systems. During the 20th century, weather has made the transition from being an equalizer to a force multiplier. Whether the mission is taking part in antisubmarine warfare, search and rescue, surveillance, or logistics/supply, the safety and mission success of Pilots and Flight Officers always depends on the atmospheric conditions. As we look upon the history, In May 1942 during the Battle of Coral Sea, two aircraft carriers named USS Lexington and Yorktown were deployed. On 08 May 1942, aviators from both ships proceeded to attack the Japanese fleet. During the strikes, Lexington's pilots used meteorological inputs from their met officer and succeeded in their strikes. The Yorktown's pilots failed in their missions due to unavailability of meteorological information[9].

Under Water Warfare

Submarine & Anti-Submarine Warfare. The greatest need for naval hydrography comes from the submarine community. There are specific hydrographic requirements for submarines that exceed that of surface navigation. Navigation under water is determined by numerous factors. The most effective method of navigation without being detected is to have hyper accurate bottom contour charts. Bottom contour charts allow the submarine to remain underwater and still minimize the risk of grounding. This is possible if there is sufficient hydrographic data and the data has been processed for submarine operations. Naval hydrography therefore bridges the gap from what is required for surface navigation and what a submariner requires to safely navigate. Naval hydrography is required to collect much better hydrographic data than required for surface navigation[10]. In the context of undersea warfare, submarine and ASW ships often exploit variations in temperature, pressure and salinity. Thermoclines, or regions of large temperature change in relatively short distances can provide barriers to sound propagation. Other factors which also affect SONAR include the topography and composition of the bottom, the surface conditions, and the ambient noise of the ocean environment[11]. Hydrographic and Oceanographic data of all seasons are required to determine sound propagation conditions. The ocean environment is an inhomogeneous variable and noisy medium. It is often unpredictable and varies both in space and time[12]. Hydrography and oceanographic data therefore enable the submariners and also ASW platforms to gather awareness of this extremely complicated environment.

[9] Charles Bates and John Fuller, America's Weather Warriors (College Station, TX: Texas A&M Press, 1986), 110.
[10] United Kingdom. Ministry of Defence, Submarine Dived Navigation: Concept of Operations v 1.0. (London: Ministry of Defence, 2011): 25.
[11] Stockholm International Peace Research Institute, Tactical and Strategic Antisubmarine Warfare (MIT Press, Cambridge, MA) 14-15.
[12] Stockholm International Peace Research Institute, Tactical and Strategic Antisubmarine Warfare (MIT Press, Cambridge, MA) 15.

Mine Warfare. Mine warfare operational decisions are influenced by local oceanic conditions. Accurate environmental parameters are important for successful mine operations. In no other littoral warfare do environmental considerations in both tactics and planning, play a more dominant role than in mine warfare. Virtually every environmental parameter in the dynamic near shore environment influences in mine operations. It is always a great challenge of the meteorological and oceanographic offices that provides the data. A thorough understanding of the coastal water column, the nature of the coastline, seafloor variability and rigidity, sub-seafloor characteristics, and the concentration of biological growth on or near the seafloor can help to ensure the mission success. Since mines are plentiful and relatively inexpensive, they are an obvious and effective war fighting alternative for cash-poor developing nations. This was exemplified during the Gulf War, where mine damage to three U.S. warships (USS Samuel B Roberts, Tripoli, and Princeton) was in excess of $125 million, whereas the mines that caused the damage, including two of World War I vintage, cost approximately $30,000[13].

Amphibious Warfare

World War II provided many hard-won lessons on the importance of hydrography to amphibious warfare. Tidal information, current, coastal topography, bottom composition and lot of other hydrographic data is very essential for planning amphibious operations. Importance of hydrographic data on amphibious warfare have been proven many times in the history of naval warfare. During the WWII in the **Battle of Tarawa**, outdated and poor data resulted in devastating results[14]. Most of the amphibious vehicles and landing craft grounded prematurely on an outer reef 600-800 yards from the Tarawa shoreline, forcing Marines to wade through the surf to the beach under heavy enemy fire[15]. Later, senior US commanders gave full weightage to employ hydrographic officers in operational planning[16]. One of the amphibious commanders designated a full staff position to his hydrographer Commander Ira Sanders, who contributed greatly to the planning and success of the final island assaults at Iwo Jima and Okinawa. During the **Korean War** in the Battle of Incheon, 1950 had been described as a classic example of operational planning. It was revealed that there are three main conclusions concerning the use of hydrographic support for the amphibious commander[17]:

a. Hydrographic support is an indispensable component of amphibious operational planning;

b. Hydrographic data is of critical importance to the operational commander's decision-making process; and

[13] Oceanography and Mine Warfare (2000), P 5
[14] Harold A. Winters and William J. Reynolds, Battling the Elements: Weather and Terrain in the Conduct of War (Baltimore, MD: Johns Hopkins Press, 1998), 221.
[15] Joseph H. Alexander, Utmost Savagery: The Three Days of Tarawa (Annapolis, MD: Naval Institute Press, 1995), 73.
[16] Charles C. Bates, HYDRO to NAVOCEANO (Rockton, IL: Corn Field Press, 2005), 82.
[17] Robert D. Heinl Jr., Victory at High Tide (New York, NY: J.B. Lippencott, 1968), 27.

c. Understanding hydrography is a core competency of amphibious operations and this relationship needs to be sustained to support the viability of amphibious operations.

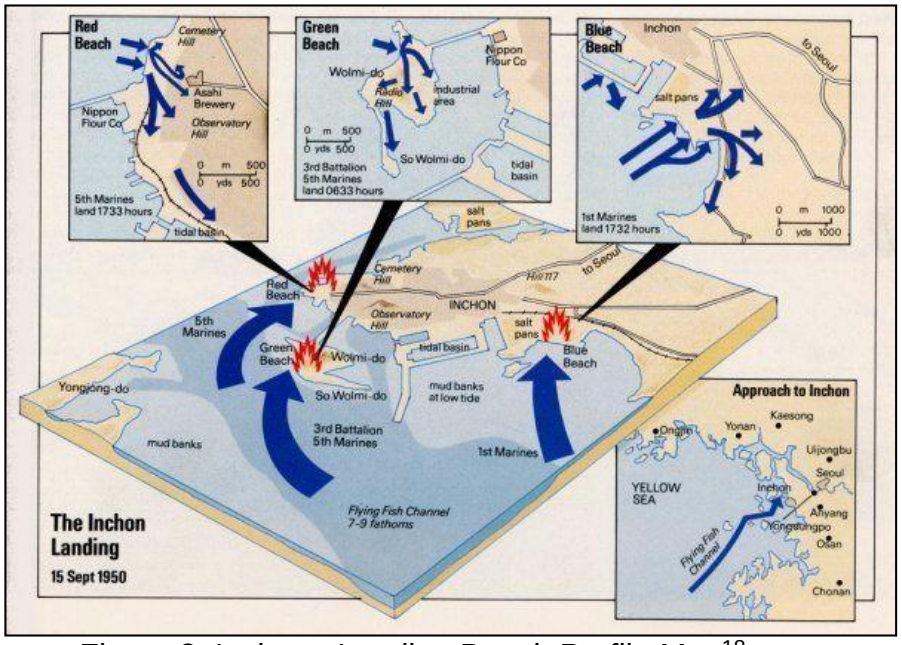


Figure 3: Incheon Landing Beach Profile Map[18]

Search and Rescue Operations

Survey ships are greatly capable of conducting maritime search and rescue operations. In addition to their usual naval capabilities, they are equipped with modern acoustic equipment to look for objects on the seafloor. Multi beam echo sounder, Side scan sonar, Magnetometer and Sub Bottom Profiler are the instrument that can help to find any object under the sea. This unique capability gives the survey ships lead role in searching for **ditched aircraft or sunken submarines**. BN survey ships have been deployed to search for aircraft wreckage more than once. During the search for missing Malaysian Aircraft MH370, approximately 60 ships from 26 nations joined the search[19]. BNS ANUSHANDHAN took part in the seafloor search in her designated sectors. Bathymetric survey and underwater search for the missing aircraft took place from May 2014 to January 2017. Many hydrographic survey and oceanographic research ships joined the massive effort. Royal Navy survey ship HMS ECHO carried out a vital role in this search. The search for MH370 collected 278,000 square kilometres of bathymetry data within the search area and 710,000 square kilometres of data in total. It is one of the largest marine surveys ever conducted. In addition to the scale of the search area, its remote location makes this bathymetric survey unique[20].

[18] https://koreanwarlegacy.org/chapters/changing-the-game-at-incheon/
[19] https://en.wikipedia.org/wiki/Search_for_Malaysia_Airlines_Flight_370#International_involvement
[20] https://www.arcgis.com/apps/Cascade/index.html?appid=038a72439bfa4d28b3dde81cc6ff3214

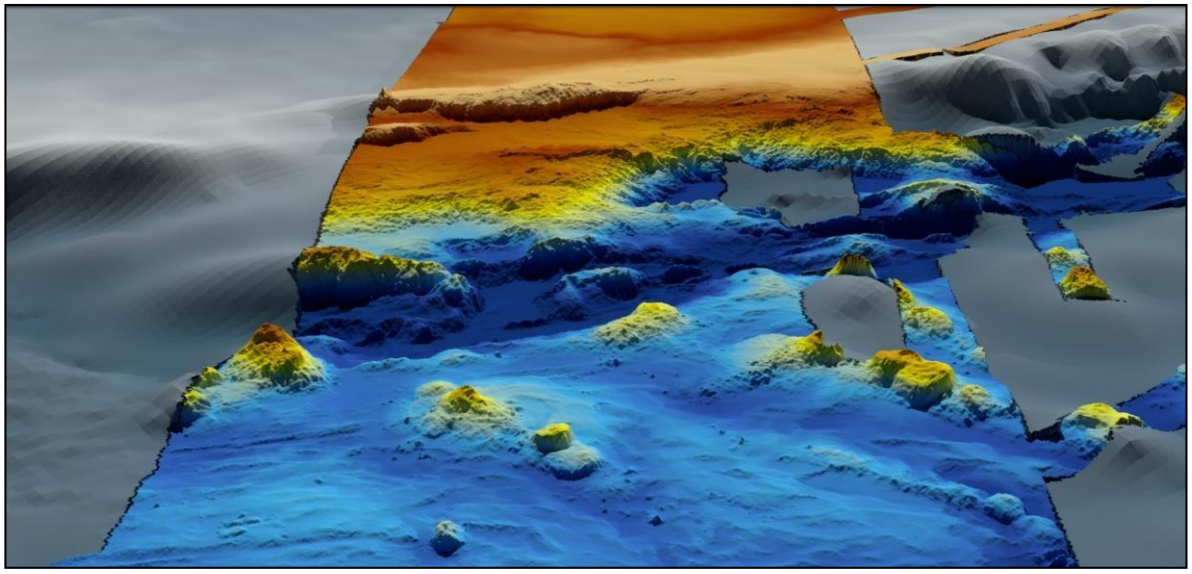


Figure 4: Seafloor search for MH370 shows the importance of survey vessels in seafloor search for missing aircraft or submarine.[21]

Traditional Need for Hydrographic Data

Navigational Safety. Government of Bangladesh has entrusted BN with the responsibility of hydrographic and oceanographic survey in the sea area of Bangladesh. As a signatory of the SOLAS convention, Bangladesh is obligated to provide hydrographic services and up-to-date information for safe navigation. As IHO member state, Bangladesh needs to produce and maintain appropriate chart scheme for facilitating safe navigation. It also facilitates growth of national economy.

Blue Economic Growth. Bangladesh Government has focused on the development of Blue Economic activities to expedite the growth rate of economy. All port areas have been increased and new ports are being constructed. Numerous offshore installations and coastal development works have started. Massive infrastructural development is taking place in the coastal belt and offshore areas. These developments will require increased amount and frequency of hydrographic surveys for infrastructural developments and safe navigation.

SDG & BDP 2100. Through the course of development, Bangladesh needs to materialize UN Sustainable Development Goals. The SDG-14 especially focuses on conservation and sustainable use of the oceans, seas and marine resources. Besides, Bangladesh Government has approved Bangladesh Delta Plan 2100 (BDP 2100) on September 04, 2018 with the aspiration of achieving 'safe, climate resilient and prosperous Delta' by 2100. All these goals are directly or indirectly related to the SDGs also. Another important thing regarding this plan is that it has strongly focused on climate change issues such as temperature rise, erratic rainfall pattern, sea level rise etc. Successful implementation of

[21] https://www.arcgis.com/apps/Cascade/index.html?appid=038a72439bfa4d28b3dde81cc6ff3214

these plans lies with the appropriate skills and technical capacity of the relevant organizations. Hydrography and Oceanography organizations will play pivotal roles to detect compliance of SDG & BDP 2100 objectives.

Operational Impact Assessment of Hydrographic Services

Having said about the operational requirement of Hydrographic Services, it is imperative now to find out the operational impact assessment basing on lessons learnt from history of Naval Warfare and BN requirement. Hence, matrix relating hydrographic, oceanographic and meteorological products & services with warfare field is constructed, and appended below:

a. Hydrographic Products

Ser	Type of Services/ Products	Usage/ Impact Time	Users	Field of Warfare
1.	Chart (Paper and ENC)	100%	Op Level: CTGs, CTFs. Tac Level: All Ships, Submarine, Aircraft	ASuW, ASW, SS Ops, Amph Ldg UCW
2.	AML	100%	Tac Level: Ships, Submarine, Aircraft	ASuW, ASW SS Ops
3.	Remote Sensing & GIS	C - Plg 50% C - Plg 50% C - 0% C - 0% I - 100% S - 100% R - 75%	Op Level: CTFs, CTGs Tac Level: CATAF, Spl Forces, Amph Forces	Amph Ldg, Spl Ops, SS Ops

Table 2: Use of Hydrographic Products/Services in Naval Ops

b. Environmental Data

Broad Category	Environmental parameter	Amph War /NSW	ASW/ USW	MIW/ MCM
Meteorology	Aerosol, haze, Smoke	YES	YES	YES
Meteorology	Air Turbulence	YES	YES	YES
Hydrography	Anchorages	YES	YES	YES
Meteorology	Baro Pressure	YES	NA	NA
Hydrography	Beach Slope, Gradient	YES	YES	YES
Oceanography	Bottom Loss	YES	YES	YES
Oceanography	Breaker Direction, Height	YES	YES	YES
Oceanography	Breaker Height	YES	YES	YES
Oceanography	Breaker Type, Interval	YES	YES	YES
Meteorology	Cloud Cover, type	YES	YES	YES

Meteorology	Clutter Density	YES	YES	YES
Oceanography	Convergence Zone	YES	YES	YES
Hydrography	Bottom & Surface Current	YES	YES	YES
Meteorology	Dew Point, Ducting	YES	YES	YES
Meteorology	Fog, Humidity	YES	YES	YES
Hydrography	Magnetic Anomalies	YES	YES	YES
Oceanography	Noise (biological)	YES	YES	YES
Meteorology	Precipitation	YES	YES	YES
Oceanography	Salinity	YES	YES	YES
Hydrography	Seafloor composition	YES	YES	YES
Hydrography	Sound Speed Profile	YES	YES	YES
Hydrography	Surf Zone Length, Width	YES	YES	YES
Meteorology	Surface Wind Dir & Sp	NA	YES	YES
Meteorology	Temperature (air, sea, land)	YES	YES	YES
Hydrography	Tides (phase, height, time, current)	YES	YES	YES
Hydrography	Topography (land)	YES	YES	YES
Hydrography	Water Clarity (turbidity)	YES	YES	YES
Hydrography	Water Depth	YES	YES	YES
Oceanography	Wave Height, period, direction	YES	YES	YES
Meteorology	Wind Aloft (direction & speed)	YES	YES	YES
Meteorology	Wind Shear (Vertical Wind Profile)	YES	YES	YES

Table 3: Relevance of Environmental Parameters to Naval Warfare Areas[22]

An Overview of BN Hydrographic Services

History. Bangladesh Navy Hydrographic Services (BNHS) started its journey by establishing Hydrographic School in 1983 at BNS ISSA KHAN in Chattogram. It paved its way with a noble aim of ensuring safe navigation at sea. This was reinstated by the government through an official gazette in the same year where Bangladesh Navy (BN) was vested with the responsibility of Hydrographic Survey in coastal and sea area of Bangladesh. In the same year two modified landing crafts, BNS DARSHAK and BNS TALLASHI were added to naval strength to carry out coastal survey. Having felt the necessity to manage and organize the distribution of charts and publications, BN Chart Depot was established in 1984. The first chart was published in the year of 1984 in ammonia print and the first colored chart was published in 1997. With the passage of time, BN Hydrographic School has been also developed. This school not only trains the officers and sailors of BN but also impart training to national maritime organizations and foreign officers. Existing BNHS fleet consists of five survey vessels: BNS ANUSHANDHAN, BNS SHAIBAL, BNS AGRADOOT, BNS DARSAK and BNS TALLASHI. Among those BNS ANUSHANDHAN (Ex HMS ROEBUCK) is fitted with the state - of - the - art equipment and

[22] The Value of Environmental Information." National Academy of Engineering and National Research Council. 2003. Environmental Information for Naval Warfare. Washington, DC: The National Academies Press. doi: 10.17226/10626.

sensors capable of surveying at deep sea. BNS DARSHAK and TALLASHI has been indigenously built and replaced the same older ships in 2020. BN Chief Hydrographer post has been created and the organization has started functioning since 27 Mar 2019. All the hydrographic ships and establishments have been placed under the control of BN Chief Hydrographer to reinvigorate the BNHS.

Modernization of BNHS. With the help of French Government, BN Hydrographic Services underwent outstanding transformation to the much needed digital hydrographic surveying capabilities under the auspices of Hydro Bangla Project-1 in 1995. The next major step of modernizing was Hydro Bangla Project-2, which was conducted in 2001. Under both the projects a good number of officers and sailors were trained both in France and in Bangladesh by the French surveyors. Later on those projects, BN shifted from analogue/conventional survey to digital survey. Those projects were the milestones to bring the BN Hydrographic Service to the international standard. After the modernization of hydrography department, the responsibility and sector of hydrographic survey increased in the manifold. But BNHS didn't have a full-fledged organization to monitor the survey works, data processing, cartographic works, storing of data, circulation and in general a research institute. Necessity was felt to establish a centre as the hub of all hydrographic activities of BN. In order to perform all those tasks, BN Hydrographic and Oceanographic Centre (BNHOC) was established in the year of 2001 at the end of Hydro Bangla Project-2 and BN Chart Depot was merged with this new organization. Establishment of this organization has given a new dimension and a wide horizon to the survey department. With the enhanced capability of international standard hydrographic survey, BNHS brought home the prestigious membership of International Hydrographic Organization (IHO) in 2001. Subsequently, BNHS was entrusted by IHO with nine international charts and eleven ENCs for the entire sea area of Bangladesh. The landmark events of BNHS is appended below:

Year	Achievement Milestone
1983	• BN Hydrographic School established at BNS ISSA Khan • BNS DARSHAK and TALLASHI (old) designated as hydrographic survey ship • Govt delegates survey responsibilities of sea area to BN
1984	• BN Chart Depot was established
1995	• Hydro Bangla Project-1 with SHOM (France) • First Digital Survey commenced
1996	• BNS SHAIBAL renovated as survey ship
2001	• Hydro Bangla Project-2 with SHOM (France) • Establishment of BNHOC
2002	• BNS AGRADOOT commissioned as survey ship
2010	• INT series chart production commences • BNS ANUSHANDHAN, a purpose-built ex-RN survey ship joins Survey fleet • Memorandum with UKHO signed for Global Distribution of INT Series

	charts
2017	• ENC Production commences at BNHOC
2019	• Establishment of Chief Hydrographer organization
2020	• 2 in no Catamaran type survey vessels BNS DARSHAK and TALLASHI (new) commissioned

Current State. BN survey fleet carry out hydrographic survey every year as per annual survey program. Special survey is also carried out as per the requirement. Oceanographic data survey and data collection is carried out in every season. BNHS is entrusted by the government to carry out hydrographic and oceanographic survey in the sea area of Bangladesh. SOLAS convention also warrant us to provide hydrographic services and up to date information that is required for the safe navigation in our waters. This is an international obligation for the country which has direct bearing towards the national economy as well. Hydrographic services have a duel role. Beside the supporting role of naval operation, it has a huge task to cover the whole ocean that belongs to our county. Our products are international hence it has the obligation to maintain the international standard laid down by IHO. Our products are used by the local and international merchant ships. We have legal bindings on our product. We have at present 51 in number national series charts, 09 in number International series charts and 11 in Numbers ENC in our inventory. These numbers are going to be increased in future. We need to carry out huge data collection. To prepare these charts require more than 04 lac NM of ships run only for the bathymetric data collection. Besides, there are other tasks also like topographic survey, coast lining, sea bed sampling, wreck/shoal investigation, oceanographic data collection etc. Again, considering the geomorphologic condition of our coastal area as its changes frequently need to be resurveyed in every 4-5 years for updating the charts. This is a phenomenal task and BN hydrographic service has lots of limitations to keep pace with the requirement. The present BN fleet consists of five hydrographic ships. Among them only BNS ANUSHANDHAN is a purpose built survey ship that can collect hydrographic and oceanographic data at sea. The newly built BNS DARSHAK and TALLASHI is a coastal survey craft. So, these fleet will be insufficient to meet the future requirement. With the expansion of naval operations in high sea, especially for submarine operation oceanographic data will be will play a vital role. The present capacity of BNHS does not commensurate with operational need of a three dimensional navy.

Surveying and Charting Status

Bangladesh Navy hydrographic services have completed hydrographic survey of all her AOR. The coastal area of Bangladesh is very dynamic due to the presence of delta. As such, keeping the chart scheme updated is a challenging task. The status and frequency of survey is severely strained due to limited assets. Following is the present status on hydrographic data gathering in the coastal areas of Bangladesh as per IHO C-55 publication.

Hydrographic surveying / Levés hydrographiques / Levantamientos hidrográficos

Survey coverage Couverture hydrographique Cobertura hidrográfica	Depth < 200m Profondeur < 200m Profundidad < 200m			Depth > 200m Profondeur > 200m Profundidad > 200m		
% Adequately surveyed Correctement hydrographié Adecuadamente levantado	100	5	0	100	5	0
% Re-survey required Nécessitant de nouveaux levés Requiere nuevo levantamiento						
% Never systematically surveyed Jamais hydrographié systématiquement Nunca levantado sistemáticamente						

Table 4: Hydrographic Surveying in Bangladesh Waters[23]

Challenges. Sea area of Bangladesh have been divided in various scales for charting requirements. There are varieties of charts in the scheme having different scales. It is observed that, for conducting the simplest SBES survey without full seafloor search, each coastal series chart requires at least 3000 nm of data acquisition run. Considering the geomorphological condition of our coastal area, re-survey is required every 4-5 years for chart update. With existing survey capability, it is extremely challenging to maintain even the coastal series charts. A summary of re-survey within current capabilities for covering the chart scheme is given below:

Ser	Chart Scale	No of Charts	Desired Survey Order	Desired Re-survey
1.	1: 700000	1	Order 2	As Required
2.	1: 350000	1	Order 2	As Required
3.	1: 300000	2	Order 1b	As Required
4.	1: 250000	2	Order 1b	As Required
5.	1: 75000	9	Order 1a	4-5 Years
6.	1: 50000	1	Order 1a	4-5 Years
7.	1: 35000	34 (25 Published)	Order 1a	4-5 Years
8.	1: 30000	3	Order 1a	4-5 Years
9.	1: 25000	3	Order 1a	2-3 Years
10.	1: 12500	4	Special Order	2-3 Years
	Total Published = 51			

Table 5: BNHS Chart Scheme

Reference	Criteria	Order 2	Order 1b	Order 1a	Special Order	Exclusive Order
Chapter 1	**Area description** (Generally)	Areas where a general description of the sea floor is considered adequate.	Areas where underkeel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Areas where underkeel clearance is considered not to be critical but features of concern to surface shipping may exist.	Areas where underkeel clearance is critical	Areas where there is strict minimum underkeel clearance and manoeuvrability criteria

Table 6: - Hydrographic Survey Area Description[24]

[23] https://iho.int/uploads/user/pubs/cb/c-55/c55.pdf
[24] IHO Publication S-44, Edition 6.0.0

It is to be remembered that, hydrographic survey also includes other major tasks as coast lining, tidal observation, topographic survey, seabed sampling, current observation, wreck/shoal investigation, oceanographic data collection etc. With the upgraded requirement of higher accuracy and more seafloor insonification, complication and effort behind each survey work is expected to be doubled. Therefore, with existing hydrographic survey vessels and manpower, it will be very difficult to regularly survey the coastal waters off Bangladesh.

Assessment of BNHS in terms of Capability

By underlining the products and services from BN hydrographic services in broad categories and based on concurrent hydrography & related service's performance standards maintained by modern three-dimensional navies, BN hydrographic service's capability can be assessed. The matrix below shows the comparative skill levels of BNHS in terms of capability to produce hydrographic, oceanographic and meteorological services required to support operations of a three-dimensional Bangladesh Navy in the 21st century.

BN Hydrographic Services Capability Matrix

Fields	Capability	No Data/ No Org	Not Cap Yet	Primary Capability	Satisfactory Capability	Mid-level Capability	Complete Competence
Hydrographic Survey	International Standard						
	Military Data Gathering						
Cartography	Paper Chart						
	ENC						
Military Cartography	AML						
	Special Charts						
Oceanography	Observation						
	Operational Use Analysis						
	Providing Training						
	R & D						
Meteorology	Observation						
	Fleet Forecast						
	R & D						
Remote Sensing	Observation						
	Analyzation						
Geospatial Intelligence for Naval Ops	Observation						
	Analyzation						
	Jt Int Prep of Btl Fd (JIPOE)						

Legends for Above Matrix

Capability Assessment Scale												
Colour Legends	Performance Standards/ Performance Levels	*Have Data for Svc*	*Have Org Setup for Svc*	*Own Cap to Collect Data*	*Cap to Process Data with QA & QC*	*Own Capability to Produce Service or Product*	*Product Satisfies Minimum Global Std*	*Product Exceeds Global Std*	*Have Expertise to Train Others*	*0~5 Year Exp*	*5~10 Year Exp*	*Above 15 Year Exp*
	No Data/ No Organization	N	N	N	N	N	N	N	N			
	Not Capable Yet	Y	Y	N	N	N	N	N	N			
	Primary Capability	Y	Y	Y	Y	Y	Y	N	N	Y		

	Satisfactory Capability	Y	Y	Y	Y	Y	Y	Y	Y	Y		
	Mid-level Capability	Y	Y	Y	Y	Y	Y	Y	Y		Y	
	Complete Competence	Y	Y	Y	Y	Y	Y	Y	Y			Y

Required Expansion of Hydrographic Services

Preferred End-state

BN Hydrographic service has gained international standards and have been able to operate on that standard for nearly a decade. With the acceleration of BN fleet expansion and its operational area, future deployment in line of a three dimensional navy, it is imperative now to look towards the enhancement of capacity and capability of BN Hydrographic Services. It is the best time to start looking another decade in the future where the hydrographic and oceanographic service's capability is sharpened enough to meet the war fighting ability of BN. Now that we have ascertained the level of impact of hydrographic and other scientific services can have over naval operation, and the current capabilities of Bangladesh Navy's hydrographic services; we can begin to gather a picture of where and how scope of improvement lies. Starting from sound strategic and operational planning to gaining tactical advantage over the enemy in the battlefield, hydrographic services will continue to play a major role. BN needs to improve the capacity and capability of hydrographic, oceanographic and meteorological services keeping pace with our operational fleets rationally. As a modern three-dimensional Navy, we need to have the ability to collect, collate and assess marine geospatial data for warfare advantage. Starting from Task Force Commander to all level of commanders and staff officers involved in planning and execution needs to have a clear understanding of the ocean environment and gain advantage over enemy. Due to the complex nature of scientific studies and long-time requirement of data gathering, improving hydrographic and scientific services for specific operational need requires good amount of time. Hence, it is the necessity now to make progress of BNHS to augment the three dimensional BN in the next decade.

Expansion of Operational Activities

Hydrographic Survey. Bangladesh Navy currently operates only one medium capability purpose-built survey ship and four other coastal survey ships. None of these ships are all-weather capable. Therefore, hydrographic and oceanographic data collection is limited to survey (winter) seasons only. Bangladesh is a deltaic country and has a unique geomorphological condition which results frequent changes of sea bed topography. As such, the frequency of the hydrographic survey of a particular area is much more than any other part of the world. With existing hydrographic survey capability, it takes more than 6-7 years to complete hydrographic survey for publishing a coastal series (1:35,000 scale) chart. There are larger scale charts, harbour charts and special charts which require much frequent updating. **BN hydrographic service should have adequate capability to reduce the turnaround time to 3-5 years from 6-7 years for coastal areas.** To meet

modern military requirement, BN survey fleet should have the capability to gather detailed bathymetric data with **precision level exceeding than that of the IHO** standards.

Nautical Charting including ENC. Currently, BN hydrographic service has 51 national series charts and 09 international series charts. The number of charts will increase in future. These charts need to be resurvey within 3-5 years to meet the international standard and also to ensure the safe navigation in our waters. We have produce only 11 cells of ENC so far. We will have to produce more than 65 cells of ENC within next decade and it is a huge task to complete and need lot of survey operations to conduct. Develop Navies use WECDIS in the warships. BN also going to introduced WECDIS in our ships. But we are yet to produce our own AML. BNHS will have to develop our own AML as per the requirement of our naval operations. Within next five years or so we should be able to produce our own AML for the use of our ships.

Oceanographic Observation & Research. For assessment of oceanographic conditions over periods of time in a year, data for all seasons need to be collected. Currently, none of the survey ship in BN fleet are all-weather capable. BN therefore needs suitable oceanographic platform where data collection and research can be carried out. We will have to make our database/ library rich and composed to support our naval operations for the next decade especially for the operations of strategic platforms. Real-time data from deployment of ocean buoys can assist quick and critical decision making.

Meteorological. BNHS does not have any meteorological observation or forecasting capability. This is another grey area that we need to focus immediately. Fully independent capacity and capability of fleet meteorological forecasting needs to be developed for ship and especially for Naval Aviation. Expansion of Naval Aviation Wing will demand accurate met inputs than ever. In fact, no single operation can be conducted at sea without a meteorological input. It is equally required for ASW, SuW, NSW, Amph Warfare etc. Marine Meteorology is our prime concern. No organization in Bangladesh is there to provide the marine inputs. So, It is us; have to develop Meteorological capacity focusing Marine weather and forecast system and of course real time Meteorological data. Scope of introducing meteorological observation satellite or sharing such assets to assist meteorological observation may be planned. BNHS should adopt a functional long time plan for the materialization of a stand-alone meteorological service in the future.

Remote Sensing and GIS. Hydrography can be enriched with the sensible application of remote sensing. Especially coastal areas with difficult access, highly indented areas are better mapped by remote sensing application. Sea surface height, sea surface roughness, coastal images can be of great help for hydrographic chart. Even Sea surface temperature and salinity can be found using remote sensing. In addition to traditional chart making, ***the Navy needs to develop GIS capability to create specialized tactical charts based on customized user requirements (i.e. topographic map, special operations map etc.).*** The ability to integrate these products with Combat Management Systems and other digital systems in use/upcoming within Navy need to be developed concurrently. Due to lack of

standardization of hardware in BN, challenges of compatibility and interoperability of any digital mapping product will prove much more challenging to BN hydrographic service. GIS and geospatial technologies form the mainstay of Hydrography – surveys, validation, processing, analysis and distribution. As GIS extends an object-relational database, it can store geographic data, perform data extraction, validation and analysis, produce digitized charts, maps and authoritative datasets.

Specialized Works. The introduction of the unmanned systems such as Autonomous Underwater Vehicles (AUVs), Unmanned Surface Vehicles (USVs), Remotely Operated Underwater Vehicles (ROVs), Maritime Autonomous Systems (MAS) and Marine Drones have tremendously changed the landscape of the bathymetry surveying industry. They can be used for commercial applications such as exploring for oil and gas or locating ship and plane wrecks, for military applications such as reconnaissance or anti-submarine warfare, and for research applications such as ocean mapping or measuring the physical properties of the water column. We need to acquire these systems and make the use of best technologies for our benefit in near future.

Expansion of Capacity

Expansion of Organization. Currently, Bangladesh Navy hydrographic service is centered on Chief Hydrographer organization. All naval hydrographic activities are accomplished by the BN Chief Hydrographer Org in coordination with Directorate of Hydrography at Naval Headquarters. However, this organization needs to expand its horizon more to support the expansion of Hydrographic Services. Because of the related nature of scientific services, separate divisions/offices may be raised under BN Chief Hydrographer.

a. **Hydrographic Centre**. For efficient hydrographic planning and management of Marine Spatial Data Infrastructure (MSDI) encompassing all hydrographic stakeholders, a national hydrographic office may play crucial leadership and management role. Currently, BNHOC under Chief Hydrographer handles all the hydrographic data processing and nautical charting coordination for sea area only. In the future, BNHOC may be upgraded to the level of national hydrographic centre. Most of the coastal nations have a national hydrographic office, headed by naval officers.

Currently, BNHOC handles most of the hydrographic data processing and nautical charting responsibilities. Survey ships' collected data is delivered to BNHOC which is ultimately converted into paper and ENC charts. BNHOC should be upgraded to the level of national hydrographic Centre. Lack of manpower always hampered the efficient function of this organization. Demand of products in future will be more and without the sufficient workforce, this organization cannot function properly. Besides the production of the chart and ENC, it will have to focus on production of own AML, BRs and Pilots. We must have our own tidal stations on the coast of the entire country.

b. **Fleet Meteorological Office**. Like most other advanced navies, a Fleet Meteorological Office (FMO) may be raised for specific naval needs. It needs to be understood that meteorological forecasts are not only useful of aviation, but also for surface and sub-surface fleet. BNHS need to adopt a 10-15 years plan to build a FMO which can support the naval operations of three dimensional navy. Starting from the infrastructure to a functional workforce combining officers and sailors need to be raised. For this to happen, a holistic approach should be implemented immediately. In the long run, we may have a separate meteorological service in the Navy, but to materialize this concept we need to raise it under BN hydrographic services.

c. **Oceanographic Centre**. A naval oceanographic centre will collect, assess and evaluate physical oceanographic data which is mostly relevant for naval operations. Users of oceanographic data are spread across military and civilian members. Therefore, oceanographic applications required for naval operations need to be developed by the naval oceanographic centre. We have not yet gathered the oceanographic data required for naval operations. Hence, it is necessary to start the acquiring the oceanographic data immediately. Such data gathering need better infrastructure and capacity which BNHS should prioritize immediately.

Inception of National Hydrographer of Bangladesh. Due to nature of marine science, all fields in this sector involve multiple stakeholders. Several ministries have different jurisdictions on their relevant matters. However, for efficient management of hydrographic, oceanographic and marine research activities, a national hydrographic office need to be established. Majority of the maritime nations have a national authority for hydrographic affairs, commonly led by a naval officer. We should also have an organization of National Hydrographic Office led by the National Hydrographer of Bangladesh under the Ministry of Defence (MOD). Such organization will have the necessary jurisdictional authority to ensure synergy between ministries/departments and professionally connected maritime stakeholders. National Hydrographer will be the apex body and the Chief Hydrographer organization will run directly under him. Presently, National Hydrographic Committee is performing the partial task in adhoc basis under MOD. A national hydrographic office ensures the balance between naval interest and economic interest as well as maritime data security. As the lead agency to spearhead Blue Economic progress, Bangladesh Navy should assume the lead role of national hydrographic activities.

Expansion of Capability

Survey Ships and Equipment. BN now have only five vessels in the survey fleet. Among them only one ship is only purpose built survey ship and others two are small survey ships for only coastal survey. BNHS is carrying out day to day survey work only. To complete the nautical charts and ENC schemes, we need more assets. Without an all-weather oceanography research vessel, it is not possible to collect oceanographic data. BNHS need a purpose-built all-weather hydrographic survey and oceanographic research vessel to

gather detailed bathymetric data with precision level exceeding than that of the IHO standards. Bangladesh Navy therefore needs to include at least one purpose built all-weather hydrographic survey and oceanographic research ships immediately and another within next five to seven years.

Training of Manpower. Expertise in hydrographic survey, oceanographic research, meteorological observation & forecast requires time to build. Therefore, sound career planning and recruitment of officers and sailors for these services are also essential to maintain a steady flow of competent manpower for these complicated tasks. It also requires sound professional knowledge and a baseline academic qualification. Here is the possible scope of adding civilian academia into scientific services in future. Military scientists or scientists in military projects are essential for enhancing research and development capability. Other than in-service training of Navy, BN hydrographic and oceanographic service will be extremely benefitted through **civil-military cooperation**. Besides, focus has to be given in BN Hydrographic School. It is the only institution in Bangladesh which is recognized by IHO to train Hydrographers and Surveyors. It is the only school which conducts professional courses on Hydrography. The school is conducting courses to BN Officers, sailors, Civil officers of Govt organization and foreign naval officers. Nevertheless, it should be raised gradually to National Hydrographic Institute, so that it can be the hub of training for hydrography and oceanography where all the military and civil stakeholders can be the beneficiary of this institute.

Conclusion

BN Hydrographic service has gained international standards and have been able to operate on that standard for more than a decade. The surge of Bangladesh Navy (BN) expansion in last few years is remarkable and the government is very supportive to develop a credible fleet with robust and dynamic support structures. The different factors associated with operations in maritime environments have made hydrographic, oceanographic and weather forecasting especially important to naval operations. Weather plays a critical role in the conduct of naval operations. In today's naval engagements, accurate depiction and forecasting of environmental conditions can be used to provide a significant advantage over an adversary. Naval operations like Above Water Warfare, Under Water Warfare, Submarine & Mine Warfare and Naval Aviation need an accurate, in-depth knowledge of the oceanic environment for essential planning and execution. Techniques for rapid oceanographic data collection, assimilation, and dissemination either directly or remotely are developing rapidly. Of the different branches of the armed services, navies have been the most susceptible to environmental conditions due to their operational environment. However, the present capability of BNHS is not in parity to support the demand of a three dimensional navy in future. A critical examination and comparison have been conducted and it clearly suggest that BNHS need to develop both in capability and capacity. Expansion of organizations or development of capability and capacity need a lengthy time in reality. With this acceleration of fleet expansion, it is the best time Bangladesh Navy

starts looking another decade ahead where the hydrographic and oceanographic service's capability is sharpened enough to meet war fighting ability of BN.

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