HydroMAOC

DEFINITION STUDY

A REGIONAL APPROACH TO IMPROVE MARINE ENVIRONMENTAL KNOWLEDGE IN WESTERN AND CENTRAL AFRICA

ENGLISH VERSION

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Introduction

How could we foresee Africa's development without considering its marine environment? The answer is quite obvious, as Africa is surrounded by around 13 million square kilometers of maritime areas under Africa's jurisdiction, including 6.5 million square kilometers of the continental shelf. And with thirty-eight coastal States of the fifty-four African States, a large part of Africa's economy relies on its maritime access, with more than 90 percent of Africa's imports and exports conducted by sea.

Nowadays, African marine environment is under a growing pressure: the increasingly use of Africa's maritime environment in several economic sectors, the raise of African population in coastal areas leading to rapid urbanization and coastward migration and of course climate change and environmental mismanagement. This situation has raised the awareness of various stakeholders of the need to sustainably manage the maritime space as a development space, leading the African Union to rightfully make the Blue Economy approach a major part of its African Agenda 2063.

However, this African awareness on Blue Economy matters dramatically falls when it comes to marine knowledge. African coastal States are not yet able to properly capitalize the knowledge related to their marine physical environment, mandatory milestone to sustainably develop, manage and conserve this African "Blue World". Actually, none of them dispose of sufficient infrastructures to produces their own international nautical charts yet or manage maritime safety and geospatial information, leaving it up to non-African entities without any long term strategy. As a matter of fact, the lack of political leverage on that matter is obvious: the International Hydrographic Organization (IHO), in charge of coordinating hydrographic offices and initiates capacity building initiatives, only counts two Member States in Western and Central Africa within its community.

Two years ago, the IHO agreed to support an initiative for the benefit of Western and Central African Coastal States to consider a more regional approach for capacity building issues. This initiative led to the *HydroMAOC* definition study in 2015, subject to the present report, coordinated by the *Service Hydrographique et Océanographique de la Marine* (SHOM – France), in charge of capacity building coordination for Western and Central Africa within the IHO. This scoping study aims at providing a regional and comprehensive capacity building programme to define how to conduct and implement a consistent set of actions to develop hydrography in West and Central Africa.

The present *HydroMAOC* report provides the main stages of that definition study, starting with a SWOT analysis of the Capacity Building organization in hydrography then investigating new areas of development for technology and skills transfer related to Marine Knowledge before describing a project proposal to build up a regional, sustainable and consolidated hydrographic capability.

1 Context and expectations

The purpose of that part is to describe the regional background and context of that study. This analysis will first address the regional context and status of the Western and central Africa towards hydrography through a SWOT matrix, taking account of the current capacity building organization with regards of past regional capacity building initiatives. Once achieved, this matrix will be exploited to determine ways forwards and areas of development in order to properly address hydrographic capacity building issues in Western and Central Africa.

1.1 SWOT analysis: Strengths, Weaknesses, Opportunities, Threats

1.1.1 The SWOT concept

SWOT analysis (acronym of *strengths, weaknesses, opportunities* and *threats*) is a methodology designed to identify and evaluate aspects of an organization (project, a business or a situation). This method is often used effectively to build organization or personal strategy to achieve a dedicated objective.

The conception of a SWOT matrix consists of identifying internal and external factors that are favorable or unfavorable to achieve that objective and sorting them in the following categories:

- Strengths, meaning the characteristics that gives the organization an advantage over others;
- Weaknesses, meaning the characteristics that represent a disadvantage relative to others;
- Opportunities, the elements that could be exploited to the advantage of the organization;
- Threats, as the elements in the environment causing trouble to the organization.

SWOT analysis considers internal and external spheres while addressing the factors seen as important to achieve an objective. The process generally considers strengths and weaknesses of the organization itself as internal factors, whereas external factors are defined by the opportunities and threats related to the environment external to the organization. Internal factors to look for within an organization may include human resources, financial matters, advantages/disadvantage of the organization and even experiences of what has worked or not worked. External factors may include matters of macroeconomic, legislation, funding sources, technological and sociocultural changes.

The results of that analysis are generally presented in the form of a matrix illustrating the four category lists, without any idea of prioritization.

SWOT Analysis		Internal Factors	
		Strengths	Weakness
External Factors	Opportunities	use the strengths to take advantage of opportunities	overcome weaknesses by taking advantage of opportunities
	Threats	use the strengths to avoid threats	minimize weaknesses to avoid threats

Figure 1: SWOT analysis concept

1.1.2 Hydrographic Capacity Building Issues in Western and central Africa

In the present study, the SWOT methodology is exploited to address capacity building organization in Hydrography in the Western and Central African region. The objective targeted in that scope is the sustainable development of hydrographic capabilities and maritime geospatial expertise within Western and central Africa. The resulting SWOT matrix is detailed in the figure 1 hereafter.

STRENGTHS (ORGANIZATION)	OPPORTUNITIES (ENVIRONMENT)
➔IHO standards, publications and bodies, ➔IHO capacity building strategy and fund.	➔Awareness of the African Union and regional bodies on maritime safety issues (MOWCA-IHO MoU on safety of maritime navigation), ➔African development assistance funding sources, ➔Perspectives of Africa's Blue Economy growth, ➔Global awareness on climate change and environmental resilience, ➔Rapid advances of ICTs (information and communication technologies), ➔Existence of recognized regional maritime academies. ➔ Development of the use of satellite data
WEAKNESSES (ORGANIZATION)	**THREATS (ENVIRONMENT)**
➔ IHO member-centric CB initiatives, ➔De facto transfer of African States' SOLAS obligations to European states, ➔ IHO unawareness from African high level decision makers (Low proportion of African coastal States in IHO membership/political leverage from IHO African coastal states representatives), ➔Lack of Regional integration to address CB issues.	➔ 'Blue World' matters vs. International funding organizations' thematic, ➔ Governance and integration of Regional bodies (Multiplicity of maritime geospatial data holders).

Figure 2: SWOT Analysis of the current CB organization in Hydrography

1.1.3 Internal factors of the current CB organization

When addressing the internal factors of the capacity building organization, the leading role of the International Hydrographic Organization (IHO) is to be outlined in the first place. Established in 1921, IHO is an intergovernmental consultative and technical organization that was initially designed to coordinate the actions and efforts of national hydrographic bodies. Now IHO aims at creating a global environment in which States provide adequate and timely hydrographic data, products and services and ensure their widest possible use. IHO aspires to be *"the authoritative worldwide hydrographic body which actively engages all coastal and interested States to advance maritime safety and efficiency and which supports the protection and sustainable use of the marine environment."*

IHO is the leading authority in hydrographic standards on various thematic such as Hydrographic surveys, International chart regulations and specifications or standards of competence for hydrographic surveyors. Those standards are indeed considered as the reference within the hydrographic community, may they be IHO/non-IHO Member States or Industry Stakeholders. Besides, IHO assumes the role of worldwide ambassador of hydrography, promoting the need for National Hydrographic Services to provide significant contribution to national maritime infrastructures towards coastal States and International bodies.

Like many organizations of that kind, IHO aims at increasing its membership. With 85 Member States, of which 8 African States, IHO remains under-represented in Africa, whereas IMO accounts for 171 Member States of which 37 African Member States over the 48 African coastal States. However, the forthcoming entry into force of the amended IHO Convention in November 2016 shall simplify the membership application process, making de facto any United Nations Member States a Member State of the IHO.

As for now, one of the main political argument to leverage coastal States to apply for IHO membership is the International Convention on the safety of Life at Sea (SOLAS). In this Convention (Chapter V, Regulation 9), ratified by most African coastal States, the hydrographic services that are to be provided by contracting Governments are clearly outlined, making this provision an obligation under an International Treaty Law. Last year, the release of an IMO mandatory audit scheme to be initiated in 2016, including the Chapter V obligations in its perimeter) has set African Coastal States in the first half of the audit schedule that started in early 2016.

Focusing on IHO capacity building (CB) strategy, capacity building is actually considered as a strategic objective by the IHO, defining it as "*the process by which the Organization assesses and assists in sustainable development and improvement of the States, to meet the objectives of the IHO and the Hydrography, Cartography and Maritime Safety obligations and recommendations described in UNCLOS, SOLAS V and other international instruments"*. In that scope, IHO provides guidance to coastal States in demand on how to develop a national hydrographic organization, particularly through the set of dedicated individual on-site technical visits. Those visits aim at providing an overview of the status of hydrography in the country. They actually rely on the IHO's three-phase capacity building strategy, which traces a path to be followed by coastal States to build a consolidated national hydrographic capability. Each phase describes a milestone in the development of a hydrographic organization, as detailed in the following table.

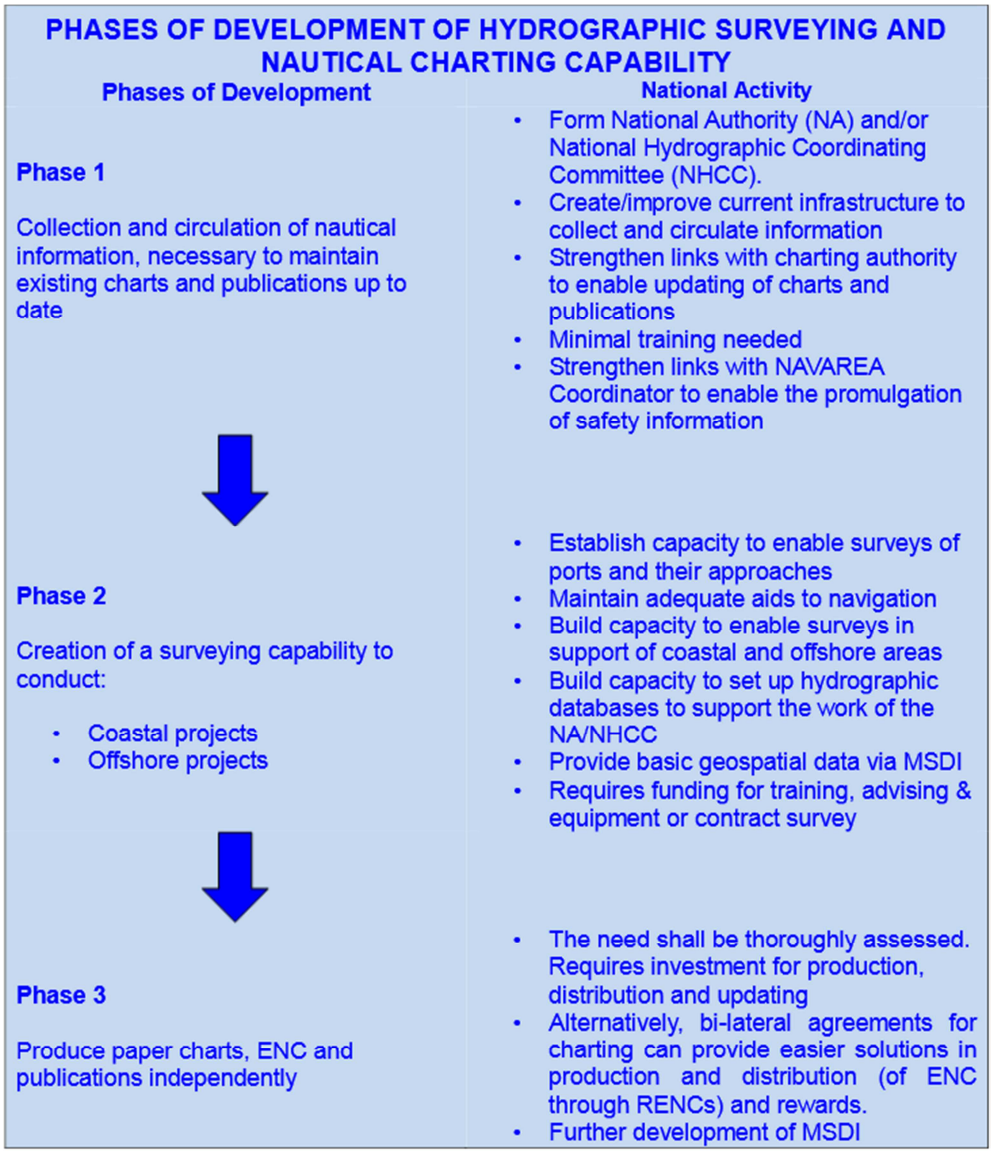

Figure 3: IHO Development phases in hydrography (source: www.iho.int)

In that scope, IHO support the development of hydrography by allocating funds to support capacity building projects schemed in yearly capacity building world programmes (CBWP), trying to match its efforts to those of other International bodies as the International Maritime Organization (IMO), the Intergovernmental Oceanographic Commission (IOC), the International Association of Lighthouse Authorities (IALA), the International Federation of Surveyors (FIG) and other organizations working in related fields. The IHO capacity building fund allocated for the year 2016 is approximately of one million euros (EUR). Over the 39 capacity building projects schemed in the 2016 CBWP, 25% are individual technical visits and 70% are educational projects (workshop, course or seminar). Regarding western and central African countries, IHO's Capacity Building action relies mostly on its regional bodies named regional hydrographic commissions (RHC), like the *Eastern Atlantic Hydrographic Commission* (EAtHC) in charge of Capacity Building actions within this region.

Nevertheless, as a membership organization, IHO focuses the benefit of its capacity building programs on its Member States: capacity building initiatives towards non-IHO Member States are

strictly narrowed to technical visits and Phase 1 projects for non-IHO Member States. With only 2 IHO Member States out of 19 coastal States in Western and Central Africa, IHO funded capacity building initiatives truly reach their limit in supporting the development of hydrography in this region. As for leverage, where the hydrographic unawareness from African high level decision makers combined challenges the development of hydrography in Western and Central Africa. The SOLAS obligations argument, used as a key argument to convince coastal States to apply for IHO membership, has a poor effect on EAtHC African Coastal States. Indeed, almost all of them have their SOLAS obligations exclusively handled by "North" States' (France, United Kingdom and Portugal), acting as Primary Charting Authority (PCA), to provide nautical charting documentations and services over their Waters, consequence of the colonial era. This exclusive transfer of responsibility is reflected by the content of the IHO S-11 International chart series catalogue for the EAtHC region: so far, Morocco is the one coastal States is involved in international chart production, in co-production with France as Morocco's official PCA.

Therefore, no Western and Central African coastal States is acting independently regarding their own SOLAS obligations on hydrographic services. And the current situation truly challenges the maintenance of existing charts and publications up to date: First of all, EAtHC African States hardly fulfills the Phase 1 requirements of the IHO three-phase strategy: according to the NAVAREA coordinating nation (France) in charge of collecting and dissemination of nautical information within the NAVAREA 2 area which comprises all EAtHC coastal States, very little nautical information comes from the official correspondents to the Coordinator: more than 40% of EAtHC African States have either no official correspondent identified or inoperative contact details. On the other hand, existing NAVAREA correspondents are not very responsive, as around 20% of them have regular contacts with the Area Coordinator (France). Those facts reflect that EAtHC costal States still do not dispose of a national infrastructure and organization able to collect and disseminate nautical information, even though they do are eligible to IHO Phase 1 projects.

This situation described previously has actually been pending during the last two decades. In 2001, an extraordinary Conference of the EAtHC Commission took the decision to form an expert team, named the Western African Action Team (WAAT) to carry out technical visits as required to the nations in which deficiencies in hydrographic development have been identified. This assessment was conducted in October and November 2002, in light of the new version SOLAS obligations on hydrographic services entered in force in July 2002. The expert team, composed of representatives from all countries having charting responsibilities in the region (France, United Kingdom and Portugal) and from the United States of America, conducted visits to 8 EAtHC States (Gabon, Nigeria, Ghana, Mauritania, Senegal, Cape Verde and Guinea. The mandate of the WAAT was the same for every visit: meeting with decision making levels of government and senior officials to emphasize on the importance of hydrography and SOLAS requirements, developing and proposing national plan of actions and milestones to answer the host-nation and international shipping needs and requirements and advice on measures to improve their national hydrographic capacities. Several follow-up actions were identified by the WAAT after conducting those visits: the first one was to encourage the creation of National Hydrographic Committees in order to dispose of appropriate representatives to consider capacity building initiatives as well as to establish survey priorities and look for maritime safety information solutions for collection and dissemination. In 2016, less than 20% of EAtHC African coastal States have formed a National Hydrographic Committee (Togo, Ghana, Nigeria). Another follow-up topic to be raised by the WAAT was education and training, as they underlined the lack of

consolidated regional training opportunities to compensate the high costs related to existing overseas courses. It recommended the promotion of training in the region with a linkage to regional training centres. Nearly 15 years after, there are still no consistent training opportunities available in Western and Central Africa. The funding issue was also raised by the WAAT, stating the variability of financial situation from one country to another prevented from providing common advice. However, the WAAT identified some funding plans to be considered for possible regional projects, mostly based on the aggregation of single income sources (port levies on ship calling). That WAAT also came along with regional projects proposals like CACAO[3] and CHARMER[4], but none of them came through by lack of a suitable funding source.

Assessment like the WAAT experience underlines that capacity building assessments rely on the commitment of three non-African Hydrographic Services handling charting responsibilities in Western and Central Africa. Those European States involvement is actually driven by the need to maintain up-to-date nautical documentations while facing a significant lack of nautical information and data and a decrease of overseas survey campaign funds. Besides, their long-lasting bilateral relationship with EAtHC African States is often seen as an alternative to the IHO strategy towards non-IHO Members when it comes to funding capacity building initiatives. Yet, there is no long-term perspective in that solution as national funds dedicated to overseas survey campaigns and bilateral cooperation projects tends to decrease: Indeed, most of the shipping routes along the coast of Western and Central Africa were last surveyed during the colonial era.

In summary, IHO is the only international organization which provides a technical framework to hydrographic activities and promotes their development. However, the limited range of its strategy towards non-IHO membership driven by the limited capacity building funds leaves EAtHC African States stuck between the hydrographic unawareness of their policymakers and the fading support from European States.

1.1.4 External factors subject to inflict the current Hydrographic CB organization

The consolidated capacity building organization designed by IHO is subject to several limitations and constraints. A closer look into Africa's development current issues and their consideration by the international community would highlight some opportunities to be considered in order to promote and develop hydrography in Western and central Africa.

The 13 million square kilometers of African maritime areas are currently under pressure, sometimes seen as a lawless zone, sometimes as an underexploited space full of natural resources, sometimes as an unprotected marine ecosystem.

Those angles of approach are subject to different level of consideration when it comes to hydrographic awareness. The first domain to raise awareness on the lack of hydrography in Africa was the maritime safety and security: in 2007, the Ministers responsible of maritime transport attending the first African Union Conference of agreed on the urgent nature of promoting and support national hydrographic infrastructures and capabilities in the scope of maintaining up-to-date hydrographic surveys and navigational products and services. Almost a decade after, this awareness-

[3] « *Cartographie des côtes d'Afrique de l'ouest* »
[4] « *Coopération Hydrographique Africaine pour des Routes Maritimes Electroniques Rénovées* »

raising approach is clearly integrated in both regional and sub-regional maritime strategies: in its 2014 integrated maritime strategy (action #2.4), the Economic Community of West African States (ECOWAS) covers the main maritime challenges of that region in four main objectives: reinforcing maritime governance, safety and security of the maritime domain, maritime environment management and optimization of ECOWAS maritime economy. Particularly, it underpins the poor hydrographic capabilities as a potential cause to pollution hazards and navigation safety issues. It also points at the lack of capability of African coastal States to chart their national Waters, which is considered as the way forward to improve maritime security and sustainable protection of marine environment within the IHO framework. Indeed, African coastal States are encouraged to consider IHO membership as well as regional cooperation in hydrography to mutualize infrastructures and capacities. The same orientation is reflected through the 2050 Africa's Integrated Maritime Strategy that identifies four building blocks for capacity building, one of which includes hydrographic infrastructures and facilities. The 2050 AIM Strategy provides the same advice towards sub-regional cooperation, capacity-building and cooperation between stakeholders to improve maritime safety of navigation. And it goes further by promoting capacity-building in the field of Maritime education and scientific research, in which hydrography is also mentioned. And like ECOWAS integrated maritime strategy, the 2050 AIM Strategy relies on the IHO Membership opportunity to "provide adequate and timely hydrographic data, products and services and ensure their widest possible use."

This African Union vision on the use of hydrography would need to be turned into concrete initiatives, as hydrographic expertise and marine knowledge remains focused on navigational safety. African Union and ECOWAS makes no doubts about the high potential of undersea natural resources and the need for their sustainable management, but do not emphasize on the crucial link between Blue Economy development and a strategic use of the related marine knowledge to ensure economic governance. Indeed, several international organizations see true perspectives in the development Blue economy sectors in African Waters: the 1.6 million tons of fish legally captured in West African waters each year represents an estimated wholesale value of US$2.5 billion. The African Union has therefore made Blue Economy one of the main items of their Agenda 2063. This major issue has also been addressed by United Nations' Economic Commission for Africa (ECA) which issued in 2016 a Policy Handbook on Africa's Blue Economy . This publication insists on the crucial need to undertake extensive mapping programmes to improve the understanding of the marine environment and its natural capital, based on the assessment of the prevailing knowledge in order to target relevant needs. It also encourages the use of dedicated research and development, based on relevant partnership and transfer of technology to improve marine knowledge. The use of existing marine knowledge gathered by marine research institutions and international organizations is also underlined. Therefore, Blue economy development has to better enhance the asset of a consistent and properly managed marine knowledge, especially hydrographic data.

Maritime governance could then be defined by its two sides, political and economic. The political side stands for the way the maritime space is governed, under which rules it is managed, secured or used as a part of a whole national or regional entity. The economic side is there to define under which regulatory framework maritime and littoral public policies and private corporate activities are to take place, particularly with the management of natural resources. Today, in an interconnected and knowledge-based world, proper maritime governance is to be safeguarded by a consistent and sustainable use of environmental knowledge, one of which is hydrographic data.

Besides, there is a transversal issue which deeply interacts with African maritime governance: the sustainable use, management and conservation of marine environment. Most African maritime strategies mentioned previously already includes it and recently, the COP21 International Conference acknowledged the critical role of the ocean to address climate change issues. COP21 discussions and decisions particularly raised awareness on the multiples challenges the African continent faces: climate change impact, unsustainable infrastructure development, inadequate management of natural habitats and resources and pollution threats are threatening the very existence of marine ecosystems. Severe shoreline losses, expected to worsen as the sea level rises, have already substantial economic impact on populations. And with a growing population in coastal areas representing 31% of the region's population, the need for consolidated maritime governance has never been so crucial: according to World Bank, approximately 500,000 people are affected each year in this region by floods and Togo's coastlines retreat by an average of 5 meters each year.

2016 has obviously led the way to action, in the frame of the 2015 Paris climate agreement. Like the joint effort between the World Bank and France in support of West African countries to strengthen the resilience of their coastal areas to climate change, and to identify opportunities for investments in the sustainable development of their 'blue' economies. In the scope of that joint initiative, the establishment of a West Africa coastal observatory to improve the knowledge base on coastal erosion, flooding and other climate change hazards along the coastal and island nations of West Africa. The observatory will be part of the West Africa Coastal Areas (WACA) program , launched by the World Bank in 2015. This platform, created in response to requests from several Western African coastal States 'aims to help countries obtain financing and expertise to sustainably manage their coastal areas.' Initiatives of that kind could greatly benefit to raise awareness on hydrography and the profile of maritime geospatial knowledge.

As with this last case, regional maritime visions and strategies need to be sustained by proper set of actions, supported by significant funding sources. And when it comes to the aid to development for the African Continent, the financial leverage is substantial: The European Development Fund (EDF), main European Union instrument for development cooperation in Africa has been implemented with EU€30.5 billion for the 2014-2020 period. The World Bank has committed up to US$42.5 billion during 2015. The African Development Bank Group has committed up to US$6.3 billion in 2015. Those funding organizations operate in targeted sectors such as health, energy, water, environment, peace and stability and good governance.

Therefore, a good way forward could be to determine how Maritime issues could be addressed through that scope, considering those significant financial flux involved. The African Development bank Group framework provides relatively promising set of transversal angles considering the development of hydrographic capabilities and marine knowledge: education and information and communication technologies (ICTs).

For the first one, the ADB Group has issued a strategy for higher education, science and technology, whose main objective is to 'assist member countries to develop the necessary science and technology-oriented skills to increase economic competitiveness and sustain growth'. To achieve that goal, the bank strategy is willing to supporting regional centers of excellence as well as infrastructures and training in specific domains, an make sure that trained students can use their knowledge skills accordingly. This holistic and integrated vision could imply the used of hydrographic

skills in Africa: as a matter of fact, there is no certified course in hydrography or marine cartography located on the Africa continent. However, Western and Central Africa dispose of well-established regional maritime educational centers, academies or universities, such as the Regional Maritime University of Accra (Ghana) and the *Académie Régionale des Sciences et Techniques de la Mer* of Abidjan (Cote d'Ivoire). Those are recognized as centers of excellence, and host regularly IHO funded hydrographic training opportunities but do not dispose of the equipment and the instructors to provide them on their own. Those regional centers could obviously be exploited to develop local hydrographic courses using modern academic methods, such as E-learning.

Regarding the ICTs, The African Development Bank (ADB) already supports the vision that development and governance are knowledge-based issues, for which ICTs should be considered as a powerful tool to achieve sustainable development and good governance. Therefore, project opportunities are already in place by the ADB to foster the development, training, experience sharing of ICTs. For many experts, ICTs represents the best way for African States to catch-up with the rest of the world for the first time and even leapfrog ahead in some areas.[5]

Going back to Funding Organizations, access to such funding mechanisms is conditioned by the requests made by African Stakeholders (coastal States or regional bodies). However, the underpinning financial opportunities highlighted previously, which could contribute to develop hydrography, are subjects to governance discrepancies at both regional and national level. On a regional scale, the lack of regional integration seems to be the main threat: with the African Union, the Economic Community of Western African States (ECOWAS), the Economic Community of Central African States (ECCAS) and the Gulf of Guinea Commission (GGC), we are talking about four different integrated maritime strategies related to Western and Central African coastal States that are to be implemented. If we consider maritime safety and security governance, two regional coordination centers seem to be working in parallel: on the one hand, the Interregional Coordination Centre (ICC) based in Yaoundé (Cameroon) sponsored and supported by ECCAS, ECOWAS and GGC and on the other hand the Information and Communication Centre (CINFOCOM) under MOWCA, based in Abidjan (Cote d'Ivoire). According to their respective mandates, they are both entitled to address criminality and piracy at sea, security and safety, environment protection by ensuring information exchange, practice and training coordination between their Member States. Even if a partnership with one of those maritime regional organizations seems necessary to promote hydrographic capacities development, the questions of their relevancy from higher level decisions and funding organizations consideration could become an issue when dealing with a multi-million regional initiative. On a national scale, frequent political instability and administrative burden prevent African coastal States from properly raising awareness on hydrography. High level political deciders do not attend IHO conferences which leaves African representatives with very limited leverage to promote hydrography in their respective country.

To summarize, current integrated regional maritime strategies for Western and Central Africa clearly consider the need for an adequate use of hydrographic data and marine knowledge as crucial to address properly maritime governance, navigational safety and security, use of natural resources and marine environment protection. That belief seems to raise international and regional organizations' awareness, particularly when it comes to Blue Economy development and Climate change

[5] African Development Bank – Economic Research Papers (N°65) - Governance in Africa: The Role for Information and Communication Technologies.

monitoring. Those strategies also encourage capacity building initiatives to be supported by sustained international partnership and insist on dedicated technology transfer. However, those testimonies of good faith do not necessarily imply the access to dedicated funds to increase capacities in marine knowledge. Indeed, maritime concern remains absent from funding organizations' main investment sectors: energy, transport, infrastructure, education, water, technology and economy.

Thus, it seems mandatory to look for connections between hydrographic capabilities development and current funding policies in Western Africa. This task, which will be developed in the following chapter, is crucial to raise awareness on the necessary inclusion of hydrographic development projects within major maritime programmes.

2 Areas of development and ways forward

Previously, the SWOT analysis addressed the current CB organization over hydrography and the focus on potential funding sources. It has underlined the need to identify potential common fields of development to increase hydrographic awareness and capabilities over major funding organizations. Nowadays, the connection between hydrographic expertise, maritime issues, regional integration and main development sectors is to be clearly established to funders and deciders so that hydrographic capacity building projects regarding Western Africa could be subject to more political leverage and funding opportunities.

2.1 Conservation and sustainably use of the oceans

"Conserve and sustainably use the oceans, seas and marine resources for sustainable development." [6]

With reference to that United Nations' sustainable development goal, the future of hydrography cannot be bound to chart production and navigational safety. It now has to stand for the expertise and management of marine geospatial knowledge collection, for the benefit of all maritime activities and stakeholders. In that perspective, benefits in domains such as Blue Economy, Marine environment protection and maritime governance needs to be emphasized.

2.1.1 Blue Economy development

The 2013 World Hydrography Day's theme addressed Hydrography as underpinning the Blue Economy: "Every human activity conducted in, on or under the sea depends on knowing the depth and the nature of the seafloor, the identification of any hazards that might exist and an understanding of the tides and the currents. Obtaining and disseminating this hydrographic knowledge is the role of the world's hydrographic surveyors and nautical cartographers. Their work is the most fundamental of all the enablers required to develop and sustain the Blue Economy."

According the Maritime Alliance, the term Blue Economy means "[…] the sum of all economic activity associated with the oceans, seas, harbours, ports and coastal zones."[7] The Blue Economy rely on the facts that the world's surface is covered by 71% of seas and oceans, and that 90% of the world's trade transits by sea. However, it would be unrelevant to narrow 'Blue Economy' as the aggregation

[6] United Nations Sustainable Development goals (Goal #14).
[7] www.themaritimealliance.org, based on The Report: State of the US, Ocean and Coastal Economies, 2009.

of fishing, maritime trade and passenger ships activities. It also includes the following activity fields non-exhaustively: aquaculture, biomedicine, boat and shipbuilding, cables and pipelines, coastal zone management, defense and security, water treatment and desalination, marine recreation, ocean energy and minerals, ocean science and observation, port operations, robotics and submarines, shoreline development, telecommunications, tourism, very large floating platforms, weather and climate science.

In that context, the importance of the efficient and sustainable use of the sea can be inferred by multiple economic facts:

Cruise ship passengers spend at least $100 each for each day ashore. That's over a quarter of a million dollars from a typical cruise ship for every day in a port
Cruise Line Industry Association
 The Oceans already provide at least 15% of animal protein for about 3 billion people, aquaculture (farming) of fish and aquatic plants is worth more than $106 billion, the fishing industry provides livelihood to more than 540 million people

UN Food and Agriculture Organization
 Well over 95% of the world's intercontinental data and telephone traffic is passed by undersea cables. The proper and safe routing of the cables depends on hydrography

Submarine Cables and the Oceans – Connecting the World. UNEP-WCMC, 2009
 High-resolution charts of scallop fishing areas in Nova Scotia, Canada, reduced trawling by 70%, increased productivity, avoided seafloor disturbance and supported sustainable fisheries management

Clearwater Seafoods Ltd; 2002
 Offshore wind farms are increasingly cost competitive with fossil fuel and nuclear sources

Green Economy in a Blue World-Synthesis Report; UNEP and others, 2012
 Port economic activity usually generates at least one other indirect job for each new job. For high tech industries this multiplier effect can reach up to 5 or 6

Moretti E, "Local Multipliers", American Economic Review, May 2012
 Economic studies show that the cost:benefit ratio for national investment in hydrography and nautical charting is always positive and can be better than 1:10

Benefit-Cost Assessment of the Canadian hydrographic Service, Brinkman & Calverley, 1992;
Analysis of the Economic Benefits of the Provision of Hydrographic Services in the APEC Region, APP & Globalworks, 2002
Ireland: Infomar Marine Mapping Study, Price Waterhouse Coopers, 2008
Scoping the Value of NOAA's Coastal Mapping Program; Leveson Consulting,2012
 For most ships, 30cm extra depth of navigable water allows at least 2,000 tonnes more cargo to be carried.

typical tonnes per centimetre tables

2.1.2 Marine environment protection and climate change

2.1.3 Maritime governance

Lack of Survey Data to Support the Blue Economy

Over the millennia the seas and oceans have fed us, provided energy and raw materials, moderated our temperature, and let us enjoy it in a multitude of ways. Yet there is still much to explore - less than10% of the world's seas and oceans have been systematically surveyed. At the beginning of the 21st century we have higher resolution maps of the Moon and Mars than we do for most of our seas and oceans.[2] While many of the world's trade routes are charted, new, larger vessels demand more accurate surveys. Any development outside the regular trade routes becomes increasingly problematic because there is little or no hydrographic data to rely on. Marine Spatial Planning which encompasses not only navigable waters but the whole maritime domain, including the shoreline, is even more demanding.

A suitable planning of maritime activities also requires relevant and accurate marine geospatial knowledge. That is even more relevant for coastal areas whose wide range of biodiversity and ecosystems meet various types of human activities. The high potential and development of littoral activities has led to a significant increase of population along the coasts: according to the 2009 World Bank annual report, 60% of world population lives within 60km next to the coastline, likely to go up to 75% in 2025.

In addition, coastal areas are amongst the most threatened by the effects of climate change: sea level rises, storms surges are more frequent and stronger. Coastal areas are also threatened by flooding and marine submersions. Large parts of western African coasts also recede from erosion. To sum up, the combined effect of waves the sea level set-up deeply affects the coastline physical characteristics on the long term.

As a matter of fact, preventing those kinds of environmental threats goes by building first an accurate set of reference data of coastal areas. Nowadays, datasets already acquired by all stakeholders are not sufficient to produce a common marine environmental picture of Western African coastal areas that could be used to properly face and address current and future environmental challenges in that region. Such a reference picture could be exploited for all sorts of applications: oil spill simulations, wave and storm surge modeling, environmental impact studies, definition of maritime highways and recommended routes to secure maritime traffic, etc.

Such a common marine environmental picture will fulfill heaps of marine environmental information needs. The main principle is the multiple uses of collected data, based on the 'collect once, use many times' principle. Information needs for coastal zone data arises from different fields, like coastal defense, shipping, fisheries, spatial planning and ecology. The information needed for coastal zone data is a crucial leverage in the choice of surveying and data processing as well as the required data quality. Another important driver is the local conditions that show large differences between different portions of Western and Central African Coasts.

Therefore, successful harmonization of different survey requires the definition of goals and the instruments to achieve them, along with the integration of the entire used instruments involved and concerned, including technical instrument accuracy in general. It also means integration of each level of data and of the different areas. At the same time it also refers to the integration of the terrestrial and marine components of the target territory, in both time and space. Thus for sustainable management of coastal systems, integrated characterization in the emerged and submerged environments of the coastal zone is needed in order to map and monitor physical and environmental parameters.

Taking these points into consideration, the achievement of a regional Common marine environmental picture is crucial for a sustainable management of coastal systems in that region. Such initiatives should first collect all past experience on collecting data in that region, then use it in an algorithm to select the most appropriate surveying method and issue a regional hydrographic data gathering programme.

2.2 Blue economy development and maritime governance

2.3 Hydrography and Education

2.3.1 Current status of Hydrographic training

The current status of the Western African region regarding hydrography in terms of education and training can be characterized by the following facts. First of all, there's no locally based training capability available in that region. The rather long distance between certified trainers mostly based in the USA and Europe and local trainees increases the training costs and therefore reduces the occurrence of such training projects. The few training opportunities organized in that region, funded by IHO, are mostly dedicated to its Member States, leaving non-IHO coastal States with limited training opportunities. Besides, in-kind contributions from bilateral cooperation, considered as another alternative, tend to be rare nowadays, and industry stakeholders' initiatives remain closely linked to equipment acquisition.

The limited resources (funds and trainers) made available by IHO's Capacity Building Fund to develop hydrographic capabilities imply consolidated management and drastic choices in the scope of the CB Work Programme to balance funds and reduce logistic costs. Once a need is expressed by one coastal State to the regional Coordinator, the time elapsed between that expression of need, the funding of an appropriated course and the nomination of a candidate is sometimes irrelevant. Candidate selection also tends to be challenging: there are few follow-up mechanisms in place able to track candidates' training history and professional background, and the guarantees that the selected candidates will fully benefit from a course in his professional path are not always provided. When an IHO funded course is organized in the region, the schedule and the timetable is not always compliant with the professional constraints of every potential candidate.

Western and Central African coastal States do have limited options to access hydrographic training opportunities. The first option is to become an IHO Member, which is in the hand of high-level political deciders, even in the scope of the new IHO Convention which will enter into force in November 2016. Besides, the quasi-exclusive provision of English courses prevents coastal states to benefit from most of IHO funded courses afterwards. The second option could come from in-kind contributions from IMO, IALA or from partner countries. The last option, and certainly the most expensive one, is either to fund an overseas training course themselves or to purchase hydrographic equipment and to include a training package provided from the contracted company.

Nowadays, the growing demand in training faces limited access to educational resources combined with a lack of multi-language sessions and materials. Therefore, exploring new ways of accessing educational resources and training development seems relevant to improve the regional

hydrographic expertise and to build up sustainable skill maintenance mechanism. The idea would not be limited to an emphasis on increasing certified hydrographic and cartographic training sessions, but to include all the expertise fields related to Marine physical environment to the regional training offer: geomatics, marine database manager, marine environment analyst (in tides, currents, maritime boundaries or coastal hazards), marine GIS developer, maritime safety information manager. All those maritime specialists would contribute to the Marine geospatial data capitalization and provide services to support Blue Economy development, Marine environment management and population safety in the maritime and littoral domain.

2.3.2 Distance learning resources and methods

A way forward to those issues could be the use of distance learning or e-learning resources. E-learning provides a permanent access to academic resources, even when the source of information and the learners are separated by time and distance. As a matter of fact, an e-learning course is not just the distribution of a face-to-face course on the Internet with the provision of digital contents available to anyone. It is another way of spreading knowledge that takes advantage of the various possibilities of digital communication techniques. Every distance learning resources requires to be done with its proper pedagogical approach: there is no use in developing a distance learning platform that duplicates, in a much poorer way, a face-to-face training course through digital contents. The E-learning approach actually takes account of the student environment, facing a computer without any trainer next to him, in order to keep him active in the learning process through a combination of practical exercises, case-studies and frequent evaluations.

However, some hydrographic skills and methods cannot be taught in front of a computer screen. When it comes to rather technical courses, e-learning sessions need to be combined with practical sessions in a blended learning process:

- Theorical principles are provided through guided e-learning sessions: trainees benefit from appropriate online materials as well as advices and a distance support from a certified trainer.
- Practical sessions, when required for dedicated topics, are provided in face-to-face mode, and their access will be conditioned to the successful completion of the guided e-learning sessions by the trainee.

In the long term, the use of e-learning resources will also safeguard the access to adequate hydrographic academic contents, opening the way to a better awareness in hydrographic expertise and allowing African regional maritime academies or universities, such as ARSTM and RMU, to rely on those contents to provide their own hydrographic related topics courses, includes them in existing educational programmes and to build up local consolidated hydrographic training programmes.

Besides, the use of E-learning course (commonly called MOOC) requires skills and competences that could be precious for capacity building matters, such as to rationalize the academic contents, to improve the access to specific educational resources and to follow-up a large student community.

In that scope, an IHO funded experimentation has been launched in 2016, which consists of experimenting distance learning technologies with the main IHO entry-level course on maritime safety information (MSI). This particular course happens to be the only training accessible to all

coastal States, IHO Member or not. In the frame of this IHO funded project, the development of digital distance learning resources followed by a test phase dedicated to African Francophone countries is to be achieved by the end of 2016.

To be fully effective, a distance learning courses requires the setup of qualified tutors to assist the students throughout the timeline and the different modules of the online course. The tutor role slightly diverts from a regular teacher but isn't incompatible: they do have the skills and experience but they are not entitled to perform academic courses online. They are trained to assist the students by answering their questions, using the communication tools made available by the MOOC platform: chats, messages, webinar, forum, etc.

As for a blended learning capability, it implies to be able to perform onsite practical sessions. As underlined previously, some specific technical skills needs to be fairly acquired through face-to-face session and experience, otherwise the interest of educational programs and their achievements is clearly at risk. The training of local trainers is crucial to acquire and maintain those competences within the region at an effective cost. For instance, the estimated cost of a MSI E-learning guided session is estimated to be 20% of the total cost of the corresponding 3 days face-to-face course.

The support from regional maritime academies, keen to develop training opportunities in hydrography and cartography, could be a major asset in the development of hydrographic training. Indeed, such academies like the ARSTM in Abidjan (Cote d'Ivoire) and the Maritime University of Accra (Ghana) have consistent experience in hosting international courses, including IHO funded courses. They are well-known in the region for providing high quality maritime training. Those academies could actually host a hydrographic department with a set of survey acquisition and data processing equipment to provide hydrographic training courses. Indeed, the theorical content of such local courses would be elaborated based on e-learning materials, allowing local trainers to comply with IHO updated and validated educational contents. Such a local training capability shall reduce the cost of onsite practical sessions and be more responsive in terms of coastal State's needs. It could also act as a regional expertise towards the coastal states to provide technical guidance and even achieve survey works for the benefit of third parties.

2.4 Information and Communication technologies (ICTs)

In that perspective, applications around maritime geospatial data is to be improved, relying on recent advances in Information and communication technologies (ICTs), particularly with Geospatial Infrastructure Solutions (GIS) and data acquisition technologies. ICTs are best seen as facilitators of change, innovation and creativity, even though they do not create transformation on their own. They have the potential to strengthen economic growth by creating new markets, new technological applications for collaboration, and new methods and tools for scientific and technological research.

As for environmental management, the applications of ICTs include multimedia public information kiosks, air and water quality monitoring, warning systems, market information, harvest management, and disease monitoring. ICTs can be used to capture and share information on advances in research and new techniques. ICTs can also facilitate agricultural extension. In the agricultural sector, ICT

applications are being promoted to facilitate wide access to information, and intensive sharing of knowledge.[8]

In that scope, regional marine special data infrastructures (MSDI) should ideally be used to address the needs of as many legitimate stakeholders as possible. Somme of the information layers that would be provided through MSDI would contain relevant information to the maritime and littoral domain. Developing ICTs tools related to marine environment and maritime activity could actually the data acquisition and its prioritizing, which can be a tedious task, considering the lack of local expertise and all the existing repositories: national maritime authorities, other national ministries, regional bodies, private companies, foreign hydrographic offices, etc. Therefore, focusing on end-user and customer needs as much as data collection process directly inflict on the design of the GIS tools and its MSDI subcomponent. Data stored in that way might improve access and build to specific products by the stakeholders.

~~Nowadays, Maritime spatial information dissemination and management is already able to rely on those technologies using Maritime Spatial Data Infrastructure (MSDI), but no such infrastructure exists for African Waters, and hydrographic data tends to be hold hermetically hold between different maritime stakeholders: Primary Charting Authorities, Oil and Gas companies, Private Surveying companies, Energy Ministries, Maritime and Port Authority. It becomes therefore crucial to make this information accessible to the widest audience and to develop associated applications and services.~~

The use of geomatics engineering in the maritime sector could spare a high amount of effort and economic resources, avoiding data to be collected twice and ensuring multiple uses for various purposes. A major outcome would consist of developing a regional maritime geospatial information web portal, together with the creation of a data management infrastructure to host and manage it. Such infrastructure shall be able to produce aggregative layers based upon data from several partners within the western and central African region and provide relevant web services and community tools to support and foster marine geospatial data manipulation and dissemination from the prepared layers by the maritime community members: collaborative cartographic tools, nautical information feedback service, vertical datum conversion tool, communication tools (chat, shared space, forums, etc).

Besides, satellite-derived activities are a relevant asset in raising awareness and access to marine geospatial knowledge in a cost efficient approach. Indeed, satellite-based technologies tends are now able to collect relevant environmental information thanks to elaborated processing methods on satellite imagery and remote sensor dataset. One of them named satellite derived bathymetry (SDB) is able to get depth information by processing water color pixels from satellite imagery. This methodology has actually been exploited for 30 years by SHOM, with the effect of minimizing on site deployment of personnel. So far, SHOM has produced more than 100 satellite derived charts supported by SDB terrain models. However, the use of SDB is constrained to shallow waters (up to 20 meters), due to the penetration of light in the water column. But thanks to the development of recent inversion models, there is no obvious link between depth range and model accuracy.

[8] African Development Bank – Economic Research Papers (N°65) - Governance in Africa: The Role for Information and Communication Technologies.

3 Building a sustainable regional hydrographic capability

In line with the analysis detailed in the previous chapter, the purpose of that next part is to provide the main principles and guidance to build-up a consolidated hydrographic capability.

3.1 Hydrographic capability core functions

A consolidated hydrographic capability can be described by the aggregation of five core functions: surveying, charting, expertise, Maritime Spatial Data Infrastructure (MSDI) and Structure, as illustrated by the following figure:

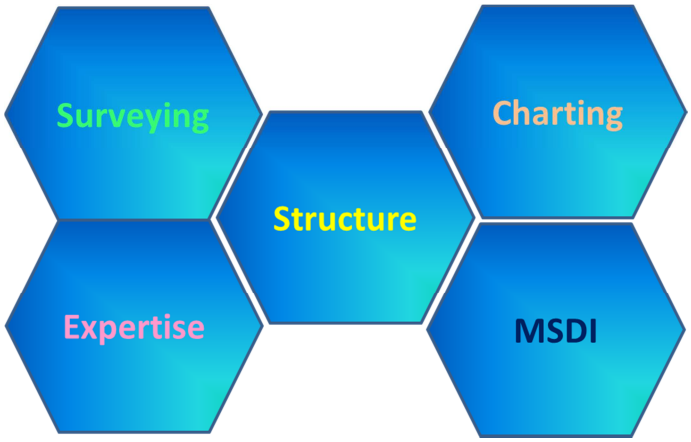

Figure 4 : Main functions of a hydrographic capability.

- 'Surveying' is the function dealing with data collection in order to get the best description of marine environment.
- 'Charting' is the one dedicated to nautical chart and documentation production.
- The 'Expertise' function encompasses all 'savoir-faire' related to hydrography that might be used by multiple stakeholders: maritime boundaries (technical support), geomatics (in relation with MSDI infrastructures), sedimentology, tides and currents, marine renewable energies (support to implantation site selection).
- The 'Maritime Spatial Data Infrastructure' (MSDI) component designed to facilitate and coordinate the exchange and sharing of maritime geospatial data and services to stakeholders from different levels in the maritime community.
- The 'Structure' component has to do with the coordination and the management of all the previous components.

3.2 Implementation plan

To be fully effective, the implementation of the hydrographic capability and its core components must be done according to several principles.

First of all, that implementation could be divided in three different fields, named the three 'E's: Education, Equipment and Empowerment. The first sector addresses all training aspects in order to dispose of skilled personnel at every level. The second one deals with the use and maintenance of

the dedicated equipment required for such a capability. The last one encompasses the definition of institutional materials (official texts, policy documents, organization chart and technical procedures) to settle that hydrographic capability in the most efficient way in the Western African maritime governance.

Although the three 'E's address distinct topics, they need to be interdependent in the overall implementation plan. Therefore, the stages need to be adequately sequenced in the overall timeline: For instance, after each training session, hydrographic personnel should dispose of dedicated equipment and technical procedures to put their skills in practice without delay. Too much delay would imply partial loss of the competences acquired through the training session by lack of practice.

	Education	Equipment	Empowerment
Surveying	➢ Surveyors/Operators ➢ Electronic experts ➢ IT experts	➢ Deployable Equipment ➢ Software/CPU ➢ Tide/GPS stations ➢ MOOCs	➢ Consolidated procedures
Charting	➢ Cartographers (Land?) ➢ MSI experts ➢ SDB experts ➢ IT experts	➢ Software ➢ Database, IT network. ➢ MOOCs	➢ Chart production plan (iaw PCA) ➢ Consolidated procedures
MSDI	➢ GIS experts ➢ IT experts	➢ IT infrastructure ➢ GIS tools/web portal ➢ MOOCs	➢ Marine Geospatial Data Policy ➢ Portal management procedures
Expertise	➢ Maritime boundaries ➢ Survey specifications ➢ Maritime spatial planning ➢ Marine energies ➢ Marine GIS tools, etc	➢ Software/CPU ➢ Database, IT network. ➢ MOOCs	➢ Connection with other admin/bodies
Structure	➢ Local tutors (MOOC) ➢ Local trainers	➢ Maintenance plan ➢ Facilities	➢ Dedicated Structure ➢ Survey Programme ➢ MSI Organization

Figure 5 : the 'E' implementation components.

Such as time synchronization, regional integration is crucial to the implementation of that hydrographic capability. In each field, the pooling of resources of the different components has to be sought in order to avoid duplication of efforts and costs and to guaranty an efficient empowerment of that hydrographic capability by western African coastal States.

The following figure provides the overall implementation timeline of the implementation in accordance with those principles. The different colors used in that figure represent the different stages for each 'E's: green color for 'education', orange color for 'equipment' and white color for 'empowerment'.

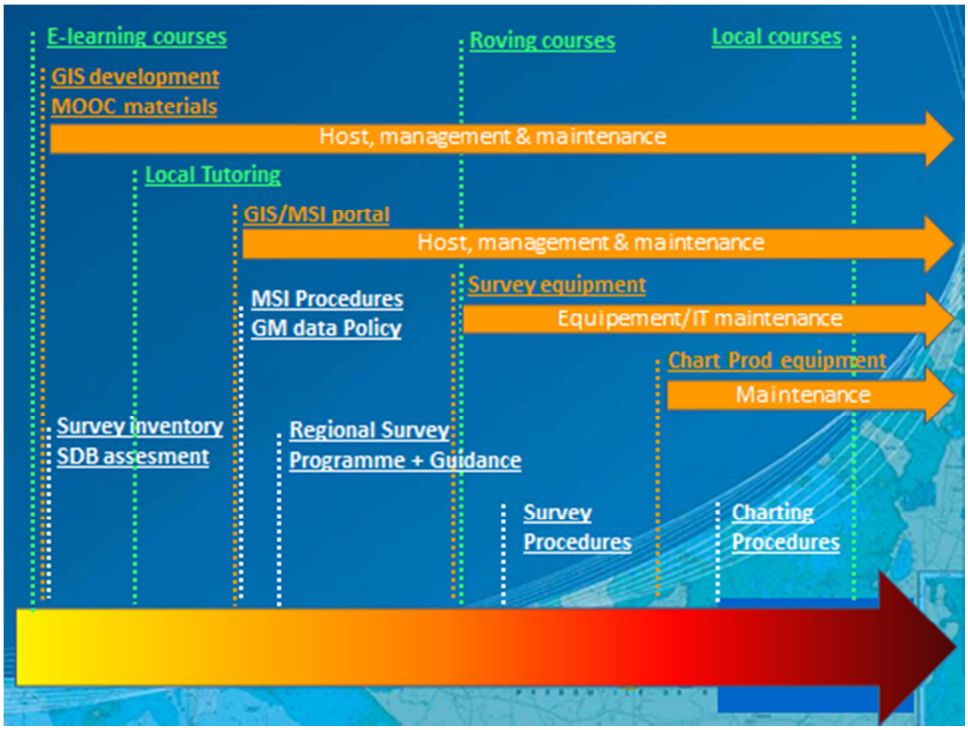

Figure 6 : Regional Hydrographic capability – Implementation timeline

The following sections details the implementation plan for each of the 'E' components in accordance with the timeline illustrated above.

3.3 Education

This component encompasses all actions related to basic training and skill maintenance capacity. All core functions detailed in the previous section requires properly trained personnel:

- The 'surveying' function requires properly trained personnel in various fields: in hydrography to conduct the survey work, in electronics and mechanic to operate and maintain survey equipment (echosounder, current profiler, GPS device, etc) and in information technology (IT) dedicated to all associated equipment (computers, software, data storage, networks, database) employed to collect and process data,
- The 'charting' function requires skilled personnel in the following domains: nautical cartography to design the chart scheme, produce the charts and keep them up-to-date and IT to deal with associated equipment (computers, software, data storage, networks, and database) employed in the production system,
- The 'expertise' function requires skilled personnel in hydrography in relation with those fields of expertise and in IT to deal with dedicated equipment (computers, software, data storage, networks, and database) used to provide technical expertise,
- The 'MSDI' function requires skilled personnel in hydrography to deal with data format and geospatial standards and in IT to deal with data storage and infrastructures (computers, software, data storage, networks, database),

- The ‘structure’ function requires jurists and administrative personnel to deal properly with hydrography and maritime geospatial data management within the maritime governance.

Most of support skills (IT, electronics, mechanics and administration) can be acquired through off-the-shelf courses. But when it takes to hydrographic skills in particular, most of the courses necessary to acquire and maintain those skills cannot be found in the region. Therefore, in line with the approach detailed in section 3.1.2, this first implementation stage would be the development of e-learning materials or MOOCs on those topics. The use of MOOCs will provide a permanent access to academic contents related to hydrography, while reducing associated logistic costs. Priority will be given to short-timed courses, tailored to acquire or maintain skills related to the hydrographic capability. In that scope, a list of potential MOOCs topics has been made with an approximate duration of the distance learning duration, which is three times longer than the academic learning process: Maritime Safety Information (60 hours), Marine GIS and MSDI infrastructure (90 hours), Technical aspects on Maritime boundaries (90 hours), Hydrography and maritime governance (60 hours), Requirement to contract out hydrographic surveys (60 hours), Field operator in hydrography (200 hours). MOOCs related to additional skills necessary to implement such a hydrographic capability will be considered, as detailed in the previous section 4.1 with the five core functions: electronics, geomatics, mechanics and information technology specialists will also be part of the education implementation plan.

The purpose of that first block of MOOCs is to improve awareness on the range of hydrographic expertise and allow multiple stakeholders involved in the Western African maritime development to benefit from them. Then, another block of more technical MOOC resources is to be developed to support future implementation of IHO certified diploma courses in hydrography and cartography.

As explained in section 3.1.2, the access of those e-learning materials will be supported by tutors within a consolidated network. Tutors will assist trainees at dedicated guided sessions, answering their questions and controlling their progresses. The purpose is to dispose of local tutors within the Western African region which will be crucial for the forthcoming blended training sessions.

Indeed, following up the MOOC development stage, regional roving courses will be set up, combining distance learning sessions and face-to-face sessions on the modules mentioned previously. The purpose of those roving courses is to skip the constraints induced by regular academic courses (costs, location) by using distance learning materials and maintain face-to-face situation for practical training requiring the use of dedicated equipment. The concept is actually to involve the regional maritime academies in the organization of those roving courses to provide human resources, infrastructures and logistical means. Moreover, those courses would be the opportunity to include local trainers by mentoring, which is necessary to maintain a training capability for skill maintenance purposes.

In the next phase, the regional maritime academies involved in the roving phase will be then be assisted to build up their own diploma courses related to hydrography and cartography (Master of Science degree, Bachelor of Science degree, IHO category A/B courses). For instance, considering the number of land cartographic institute all over Western Africa, designing a marine cartography course dedicated to land cartographers could be cost and time efficient for all.

Lastly, a crucial aspect to consider while implementing the 'education' component is the language issue. More than half of Western Africa coastal States are either francophone or Portuguese-speaking. However, most training materials are available in English, like most courses provided in the region. This reduces the spectra of training opportunities. Potential recipients are then constrained to develop their English skills before applying to proper training sessions. Even though this approach may be cost-efficient, it does not comply with a consistent approach towards western African stakeholders. Therefore, MOOCs will include multi-language access to materials, and roving/local courses will have to be provided in both languages to ensure that skills are properly acquired by trainees.

3.4 Equipment

The first stage of the implementation of that component will be the development and provision of e-learning materials. Those contents will be made available through a MOOC platform (website) with adequate management and technical support. It could be cost-efficient and profile-raising to seek out partnership with existing MOOC platform, such as IMarEST's Marine Learning Alliance[9] or CIDCO's distance learning platform[10]. But the best profile-raising opportunity for this regional hydrographic capacity building project would probably be to combine efforts with the Ocean Teacher Global Academy project[11] of the "Intergovernmental Oceanographic Commission" (IOC). This objective of this project is to support IOC's "International Oceanographic Data and Information Exchange" (IODE) training activities with the provision of tools for oceanographic data and information management. These tools were but can also be used for academic training activities, self-training and continuous professional development. Since 2006, 'Ocean Teacher' also provides knowledge and training materials related to operational oceanography and marine meteorology using Moodle software.

As for the provision of equipment and tools related to the core functions, the following materials have been identified:

- The 'surveying' function requires various equipment to collect all data related to physical marine environment, such as echosounder, side scan sonar, GPS receiver, inertial motion sensor, sound velocity profiler, tide and current profilers. It also requires specific data acquisition and processing software. As the equipment needs to be operated at sea using nautical means (vessel, launch), the choice of deployable sets of survey equipment would be more adequate to comply with the nautical means used by the recipients. The main benefit of that option is the provision of a cost-efficient, easy-to-use solution.
- The 'charting' function requires specific tools to produce nautical chart and documents, such as chart production and data processing software and professional printers. IT infrastructure is also required to build up dedicated databases,
- The 'expertise' function also requires specific GIS tools, software and databases,

[9] https://www.mla-uk.com/
[10] http://cidcomoodle.ca/moodle28/
[11] http://www.oceanteacher.org

- The ‘MSDI’ function encompasses all spatial data infrastructures required to support the activity related to the previous functions: Databases, web portals and online services data storage and other IT systems.

The provision of that equipment will have to be phased with the training sessions, so recipients can practice their skills, and future local trainers to be fully operative to ensure the whole spectra of hydrographic training. Moreover, maintenance framework and support would have to be included while providing to guaranty a sustainable use of that equipment.

As for the implementation of a maritime spatial data infrastructures required for the ‘MSDI’ function, the regional integration card has to be raised to optimize the profile of maritime geospatial knowledge of that region. For that purpose, the support of information and communication technologies is crucial to guaranty the best use of that knowledge by all maritime stakeholders as a support to Blue Economy development and maritime governance in the Western African region. Therefore, the development of a regional maritime geospatial information data portal has to go beyond a regional maritime atlas restrained to data visualization and retrieval. Such a data portal has to include collaborative tools and services available to the widest range of users. Several online services would then be implemented from that maritime spatial data infrastructure:

- datum-converter tool to edit the vertical datum of your bathymetric data,
- tide prediction build-in tool,
- 3-D current visualization tool,
- real-time maritime traffic flux visualization tool,
- external data import tool to visualization information layers from other sources,
- a dynamic cartographic environment which allows all users to create their own maps taking benefit from the portal’s data and build-in edition tools and to share them online with other users for collaborative work purposes,
- an online a nautical information feedback service, allowing maritime stakeholders, may they be general public, port authority or private companies to report on any navigational hazards or information concerning depth, wrecks, coastlines, buoys to maritime administrations and primary charting authorities.

This provision of online services should be continued to support Blue Economy development, Maritime Public Policies, Marine environment protection, Safety of life at sea, coastal hazards.

In the scope of that study, a GIS experimentation has been done, based SHOM’s maritime geospatial data portal. The purpose was to gather various sets of maritime spatial data over Western Africa together and to compare that solution with those used by different stakeholders. Data sets were then collected from SHOM (France), UKHO (United Kingdom) and IHPT (Portugal) together with Open data sources (GEBCO). The purpose of that demonstrator was to give a glance of what a western Africa maritime portal could be, based on off-the-shelf technologies and datasets.

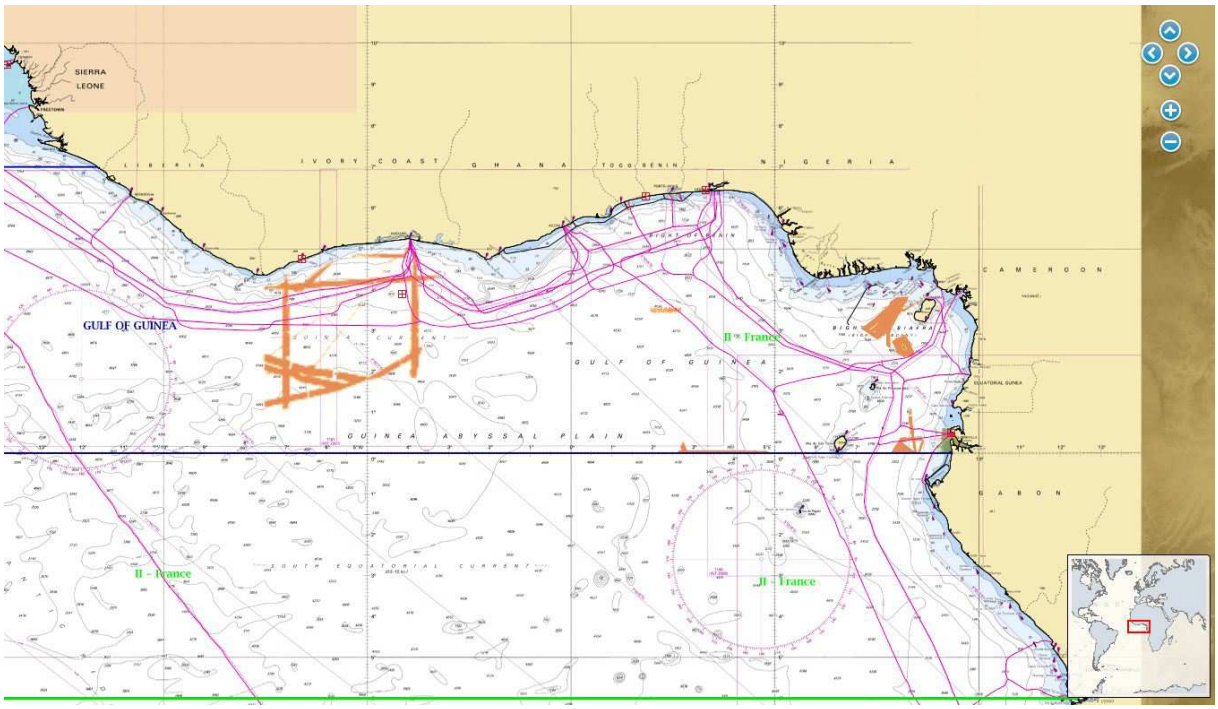

Figure 7 : Map area from Western and Central Africa GIS model

3.5 Empowerment

The success of the implementation of such a regional capability is conditioned by the definition of a consolidated framework, so that the technology and skills transfer achieved by the other 'E' components will not remain unfruitful. At each implementation stage, stakeholders are provided with consolidated procedures (planning, organization, methods) for each of the core functions implemented. The provision has to be phased with the 'education' and 'equipment' stages detailed previously:

- The surveying function requires a regional hydrographic programme and documentation detailing the rules of procedures and operating methods based on the IHO standards, particularly its S-44 norm for hydrographic surveys,
- The charting function requires a chart production plan, a maritime safety information organization and consolidated procedures based on the IHO and International Charting Authority (ICA) standards,
- The MSDI function requires a maritime spatial data policy and consolidated procedures in accordance with geospatial information standards: ISO/TC 211, Open Geospatial Consortium (OGC) and IHO standards,
- The expertise function needs consolidated procedures and, if needed, a legal framework (law, engagement letter, contract) to formalize the support provided to maritime stakeholders,

As for the surveying function, the achievement of a regional hydrographic programme is crucial to dispose of a data collection plan to achieve a common marine environmental picture for the purpose of a sustainable management of the maritime and littoral domain. This task would be composed of three phases: first collect all experience on collecting data in that region and evaluate

potential for new technologies (satellite derived bathymetry, autonomous underwater vehicles, etc), then use them in an algorithm to select the most appropriate surveying method to collect data and lastly issue the hydrographic programme itself.

Several techniques have been used to map different coastal features such as bathymetry, shoreline position, habitat, barrier island migration, and dune erosion. The methods differ both for instruments and survey platform (naval, aerial or satellite). It does not exist a best all-round technique, but each instrument has been adopted or preferred accordingly to its optimal operating conditions that depends on environmental factors (i.e. depth range, turbidity, distance from coast, vertical and horizontal tide range...), target area (i.e. deep water, shallow water, intertidal area, emerged coast) and information that can be acquired and mapped (i.e. coast line, bathymetry/topography, morphology, habitat, characteristic of sediments such as grain size, mineralogy and chemistry) and purpose of the survey (i.e. for navigational safety, scientific knowledge or commercial exploitation). Often a combination of techniques is applied for mapping the coastal zone, like echo sounding for the water and LiDAR for the landside.

This inventory phase would gather experience on instruments and methods that have been operated from various platforms (ships or autonomous underwater vehicles, aircrafts or drones, satellites), depending on the above factors: Single Beam Echo Sounder 31 (SBES), Multi Beam Echo Sounder (MBES), Side Scan Sonar (SSS), LiDAR, SAR (Synthetic Aperture Radar), Hyperspectral/Optical Camera, Orthophotos, Field Radiometry (water color) and Sampling (sediments). All the gathered survey experiences will then be analyzed and summarized by date, geographical area, coverage, purpose, operating conditions, details of contract and techniques used, results in a final referenced report describing work. The result will be a report of the listing and summarizing past experience with a set of geo-referenced data layers synthetizing all those information.

An algorithm will then be developed to help the coast survey planning at regional level. The algorithm will use a multi-criteria aid to decision model to indicate the most suitable survey techniques to use in each stretch of coast to obtain the required product. The algorithm will integrate in the process the knowledge gathered from literature, the infield experience of the partners and the available information on the environmental condition of the coastal site and will indicate the most suitable survey techniques along with their achievable products and cost. The results of the model will be supplied with a suitability index that will describe how much each technique matches the purpose of the survey and the environmental condition of the site.

This index will help in the planning phase to compare the different techniques and to have a measure of the accuracy of the choice. The algorithm will also consider the possible synergistic use during the same acquisition between products and instrument that could permit to reduce mobilization and demobilization under the same time of the survey. In the end, a consolidated regional hydrographic programme based on these survey method algorithm results and crossed with information priority needs shall be generated.

3.6 Risk analysis

The different options chosen to implement that regional hydrographic capability come with potential risks, which are analyzed in the following section.

3.6.1 Funding opportunities

The overall cost of that regional hydrographic capability through this implementation plan is nearly 10 millions Euros (€). The implementation plan has been designed for a five years period. The overall breakdown of costs is provided through the table and detailed action plan in annex II.
Alongside that implementation of that regional capability, it is necessary to credit some funds to marine geospatial data collection activities such as hydrographic surveys. Therefore, another 5 millions Euros (€) could be earmarked to ensure those activities, provided that EAtHC coastal States would gradually take over data collection activities to maintain a relevant and accurate marine geospatial dataset necessary to maintain expertise, services and tools developed to support Blue Economy, Maritime Governance and Environmental protection.
Now, considering the strategies put in place by international funding organizations detailed in the first chapter, such a regional capacity building project focused on hydrography is very unlikely to be funded as a full project. The risk associated is that, like previous regional projects designed for the EAtHC region, the project proposal explicated in this report remains a draft project.
Therefore, several options are available to reduce that risk: the most efficient one would be to integrate it in a larger scale maritime/environmental/climate development programme. This requires consolidated relationships with International funding organizations, precisely to get an overview on their projects pipes in order to seek synergies with hydrographic awareness. For instance, the ADB funding policy includes fiduciary funds dedicated to environmental and climate change matters. National projects opportunities would be included in that research scope, as an implementation by parties involving coastal States with significant awareness on hydrography in the Western and Central African region would eventually succeed thanks to the existing 'snowball' effect. Another option would be to lobby those International funding organizations in order to integrate the 'Blue World' development and management as a specific transverse sector, based on the fact that marine renewable energies, maritime spatial planning, action of the state at sea, Blue economy are marine geospatial knowledge-based activities.

3.6.2 The educational approach

As for the education component, the risk identified in that implementation are the inconsistency of that learning approach, the reliability of the economic model and the sustainability of local tutors and trainers networks. As for the first risk, the IHO has funded a e-learning experimentation project in 2016 to provide guidance and good practices for the use e-learning in hydrography training. Moreover, the e-learning implementation is focused the use of a pedagogic approach and blended e-learning processes rather than pure computer assisted training. This blended approach mixes distance learning phases with face-to-face practical workshops. The use of a specific pedagogical approach while developing those e-learning resources, enabling continuous assessment methodology and a demanding an active participation from the student shall improve the efficiency of such course.

The second risk related to the economic model of that educational approach is compensated by the strong cost-killing effect due to the reduction of travel fees and other logistic expenses specific to face-to-face courses. Moreover, IHO guided sessions scheduled for those e-learning modules, dedicated to IHO selected candidates, could be opened to external candidates at certain times. Indeed, the perspective of a wider range of IHO approved course could be of interest for non-IHO

members, other ‘non-hydrography related’ administration or private sector stakeholders, even if they have to pay for it. Besides, onsite regional capabilities in charge of onsite practical sessions and skill maintenance could also be tasked as a proper regional expertise pole and achieve some survey work for the benefit of coastal States in that region, which could be a potential source of incomes to contribute maintaining the capability and its equipment.

The third risk is compensated by the interest regional maritime academies have already shown to the outcomes of that definition study and taking part of that project. Those structures might be able to maintain that tutor network as part of their pedagogical team as any other structure. Furthermore, the existing hydrographic community could step up in that distance tutoring role, especially if it lowers the workload compared to the existing face-to-face training courses.

3.6.3 Equipment and infrastructure sustainability

The main risk identified in that scope is the sustainability of region-based infrastructures and equipment pool. As for the survey equipment, Priority must be given to simple, easy-to-use and deployable technology to take advantage of existing nautical means operated by recipients. The development of e-learning materials must focus on the use of freeware solutions as far as they are fulfills the pedagogic requirements, objectives and the international norms of competences for hydrographic and cartographic training.

Concerning the chart production and data infrastructures, priority will be given to existing local capabilities within the region such as land cartographic centres, oceanographic institutes or regional maritime bodies.

Concerning the education materials and infrastructures, support from existing maritime academies is crucial to raise the profile of hydrographic training and ensure consolidated technology and skills transfer all over the Western African region.

Conclusion

ANNEXE I

REGIONAL HYDROGRAPHIC CAPABILITY - ACTION PLAN

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
MANAG-STRA	**STRATEGIC MANAGEMENT** **Having political guidance in order to propose the establishment of resources. Establish and allow to defend the global issues at high level**					
MANAG-STRA-1	Adapt the strategy and operation of the IHO CB	Too restrictive vis-à-vis the African countries not members of the IHO	OHI CBSC EAtHC/CB (SHOM)	Revision or implementation of exemptions	CBSC meetings EAtHC meetings	No
MANAG-STRA-2	Raise the "statements of interest" outside IHO	These are exogenous initiatives that will enable new advances	OHI Directors Présidents : EAtHC, CBSC …	Visits and interviews authorizing a high level "lobbying"		8 k€/year
MANAG-TRANS	**TRANSITIONAL MANAGEMENT PROJECT** **To live the project and overcome the lack of resources before it is launched and financed**					
MANAG-TRANS-1	Complete 2015/2016 study (first version with actions that can be considered as options) Maintain contacts Support (pending their funding) the actions validated by strongly involving African nationals (Project team building, project implementation organization) in connection with the current cartographic authorities (SHOM, UKHO, IHPT)	The study can always be consolidated (some topics may be further deepened) (CBSC and EAtHC 2016 may have requested additional) (funding should always be sought). The dynamic created must be maintained	OHI CBSC EAtHC /CB (SHOM)	Collect stakeholder opinion on first draft (internal IHO CBSC, EAtHC)	In two times : From the 2nd quarter of 2016 (after next CBSC: 24-26 May 16) Then during EAtHC 18-20 October 16	20 k€
MANAG-TRANS-2	Start the process of project financial support (call for proposals for a program	Need to launch a process financially supported upstream	OHI CBSC EAtHC /CB	Could mainly take the form of a Call for Proposals (eg, EU)	2017	80 k€

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
	encompassing but not neglecting specific financing obtainable elsewhere)	of phase "PROJECT IMPLEMENTATION" In order to get a detailed definition of the scope of the program carried by Africans and conform to requirements of donors	(SHOM)	whose objective would be to achieve the drafting of terms of reference of the project to prepare one or tenders. The possibilities for specific funding (Targeted themes, bilateral cooperation between countries ...) will also be analyzed to be implemented in addition to or in partial substitution of the overall project.		
MANAG-PROJ	**MANAGEMENT PROJECT Organization / project governance (monitoring of actions and use of resources, cost / time / objectives, risk management, team building project related costs: fees, travel ...)**					
MANAG-PROJ-1	Confide to an engineering company project control tasks	It takes a team and an organization "Project" legitimate, strong and powerful	expert in project management (compatible with rules of the clients that are the financers: a permanent project manager + part-time experts)	Election on tender on terms of reference (specifications).	From the beginning of the project (2017)	300 k€/year
MANAG-PROJ-2	Support existing chart makers (PCA: primary authority chart) in their responsibilities to	It is necessary to organize the transfert and to meet the costs	The current chart makers:SHOM,	Match commitments in European countries within the region	Duration of program	200 k€/year

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
	transfer skills and knowledge (data)		UKHO, IHPT	(Distribution in first approach: 50% SHOM, 25% UKHO, 25 IHPT)		
PROG	**HYDROGRAPHIC AND CARTOGRAPHIC OPERATIONAL PROGRAMME OF PRODUCTION** **Develop national and regional plans for hydrography and cartography (in line with the implementation of capacity) production**					
PROG-1	Prioritization of actions	To address the most urgent needs taking into account the capacity / resources	Supervision (of the outsourcing) by the current chart makers : SHOM, UKHO, IHPT in conjunction with the authorities of the countries concerned by navigation)	Risk analysis based on the inventory of existing data (including their qualifications compared to standards) crossed with the navigation uses (and risks on: goods, people, environment)	Initial phase of the development program (2017)	100 k€
PROG-2	National multiannual programs	Governance	National authority (PCA support)		From 2017	Intégrated in MANAG-PROJ-2
PROG-3	National multiannual programs	Governance	International organization (cross-border) (support of cartography responsible)		From 2017	Intégrated in MANAG-PROJ-2

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
EQUIP	**MATERIAL RESOURCES – EQUIPMENT SUSTANAIBLE** **Set up material resources (management and dissemination of data and maritime safety information, Hydrography: equipment and software acquisition and data processing, charting) and for their operational maintenance (boats and infrastructures excluded)** **Nota : no actions (or financing provided) to boats and onshore infrastructure**					

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
EQUIP-1	Management and dissemination of data and maritime safety information (portal) Management (hosting) of an interim center precursor of regional centers. Design support	Users relations International obligations	Among : SHOM/UKHO/IHPT	Duplication of at least an existing portal. (would lay out the African regional portals	2017 and 2018	50 k€/year
EQUIP-2	Management and dissemination of data and maritime safety information (portal) Establishment of regional centers (2017-2020)	Users relations International obligations	Engineering company	Design-development-Definition	2017-2020	150 k€/year
EQUIP-3	Hydrography : allow 5 countries per year to acquire basic hydrographic equipment and know how to use	No development without means No recurrent training without means	Engineering company	Purchase of light hydrographic systems that can adapt easily to existing boat or launches. Purchase of training (adaptation training: initial implementation)	2017-2020	300 k€/year (5*60)
EQUIP-4	Charting : allow 5 countries per year to acquire basic charting equipment and know how to use	No development without means No recurrent training without means	Engineering company	Purchase of charting systems Purchase of training (adaptation training: initial implementation)	2017-2020	100 k€/year (5*20)
EQUIP-5	Form a traveling and versatile team (hydrography, charting, Management and dissemination of data information technical support on equipment and software) allowing 5 interventions per year in	No systems without capacity in operational maintenance	Engineering company	Subcontracting	2017-2020	280 k€/year

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
	the region (optimizing the use of existing resources, repairs)					
HUMAN	HUMAN RESSOURCES Develop the skills of human resources in the three main languages (French, English, Portuguese) and be independent in future Nota : no actions (or planned financing) for personal expenses that represent the constitution of the workforce and their remuneration and their travel to access training. Personal to be trained are expected to have acquired basic math knowledge, physics, language. Nota : the implementation of face to face training are supported (twinning) by existing training centers in three languages. At the end of the project African centers are autonomous for theirs trainers (training African trainers was privileged) Nota : it is not, at this stage, proposed to set up approved CAT A hydrographic training. It remains that there are hydrographic engineers to be formed, and that, in future, there is no reason why the corresponding formations would not be not given on the African continent					
HUMAN-1	Access to existing courses in hydrography and nautical charting	We must make into account the transition and train future trainers	Approved schools FIG/IHO	Allow each regional training center to have (own or as temporary) one CAT A in hydrography, two CAT B in hydrography, and one CAT B in nautical charting	2017-2019	200 k€/year on 3 years
HUMAN-2	Access to existing courses on themes and related professions	Hydrography covers many areas subject to capacity building actions	UNESCO / IOC, the FIG / ICA, IMO MOWCA PMAWCA ...)	Make advantage of existing opportunities to develop skills in an extended scientific and operational framework, (Oceanography and management of the sea environment and coastal management and inland waters, land geomatics, aids to navigation, dredging, navigation, port operations, sea state action (safety, maritime boundaries, law ...)	2017-2020	50 k€/year

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
HUMAN-3	Establish new "face-to-face" courses in regional centers: continuing education (training) Training of surveyors operators	At the base of the hydrographic profession (data acquisition)	Regional schools	Training 10 days	2017-2020	45 k€/year (3*15)
HUMAN-4	Establish new "face-to-face" courses in regional centers: continuing education (training) Training of senior technicians	Ensure essential basic knowledge in: hydrography, charting, dissemination of information, maintenance of equipment	Regional schools	Training 50 days	2017-2020	150 k€/year (3*50)
HUMAN-5	Establish new "face-to-face" courses in regional centers: continuing education (training) Training managers	There is no development without governance	Regional schools	Training 10 days	2017-2020	45 k€/year (3*15)
HUMAN-6	Establish new "face-to-face" courses in regional centers: certified CAT B training in hydrography	Skill level in the heart of the job	Regional schools	6 months training provided the first year by teachers (2) from hydrographic schools (approved programs). Twinning later. Provision of basic equipment.	2017 - 2018	600 k€ first year (3*200) 150 k€ next year (3*50)
HUMAN-7	Establish new "face-to-face" courses in regional centers: certified CAT B training in nautical charting	Skill level in the heart of the job	Regional schools	6 months training provided the first year by teachers (2) from hydrographic schools (approved programs). Twinning later. Provision of basic equipment.	2018 - 2019	600 k€ first year (3*200) 150 k€ next year (3*50)

N° Action	Object Action	Why	Who	How	When Circumstances	Ressources
HUMAN-8	Implement e-learning	effective methods	Hydrographic school	Gradual implementation in the three languages. Consistent and in supplement to face-to-face training	2017-2020	150 k€/year (3*50)

ANNEXE II

WESTERN AFRICA HYDROGRAPHIC CAPABILITY

BREAKDOWN OF COSTS

2							
3	**MANAG-STRA: Strategic management**	**2016**	**2017**	**2018**	**2019**	**2020**	Total line
4	1: IHO strategy	0	0	0	0	0	0
5	2: lobbying		8	8	8	8	32
6							
7	Subtotal	0	8	8	8	8	32
8							
9	**MANAG-TRANS: Transitional management project**	**2016**	**2017**	**2018**	**2019**	**2020**	Total line
10	1: complement, maintain contacts	20	0	0	0	0	20
11	2: call for proposals	0	80	0	0	0	80
12							
13	Subtotall	20	80	0	0	0	100
14							
15	**MANAG-PROJ: Management project**	**2016**	**2017**	**2018**	**2019**	**2020**	Total line
16	1:Confide to an engineering company project control tasks	0	300	300	300	300	1 200
17	2: Support existing chart makers	0	200	200	200	200	800
18							
19	Subtotal	0	500	500	500	500	2 000
20							
21	**PROG: Operational program of production (Hydro, carto)**	**2016**	**2017**	**2018**	**2019**	**2020**	Total line
22	1: National multiannual programs	0	100	0	0	0	100
23	2: National multiannual programs	0	0	0	0	0	0
24	3: National multiannual programs	0	0	0	0	0	0
25							
26	Subtotal	0	100	0	0	0	100
27							
28	**QUIP: Material resources Equipment Sustainable maintenanc**	**2016**	**2017**	**2018**	**2019**	**2020**	Total line
29	1: Management (hosting) of an interim center precursor of regional centers	0	50	50	0	0	100
30	2: Establishment of regional centers	0	150	150	150	150	600
31	3: allow 5 countries per year to acquire basic hydrographic equipment	0	300	300	300	300	1 200
32	4: allow 5 countries per year to acquire basic charting equipment	0	100	100	100	100	400
33	5: Form a traveling and versatile team Maintenance	0	280	280	280	280	1 120
34							
35	Subtotal	0	880	880	830	830	3 420
36							
37	**HUMAN: Human ressources**	**2016**	**2017**	**2018**	**2019**	**2020**	Total line
38	1: Access to existing courses in hydrography and nautical charting	0	200	200	200	0	600
39	2: Access to existing courses on themes and related professions	0	50	50	50	50	200
40	3:"face-to-face" courses : Training of surveyors operators	0	45	45	45	45	180
41	4:"face-to-face" courses Training of senior technicians	0	150	150	150	150	600
42	5:"face-to-face" courses Training managers	0	45	45	45	45	180
43	6:"face-to-face" courses Certified CAT B training in hydrography	0	600	150	0	0	750
44	7:"face-to-face" Certified CAT B training in nautical charting	0	0	600	150	0	750
45	8: Implement e-learning	0	150	150	150	150	600
46							
47	Subtotal	0	1240	1390	790	440	3860
48							
49	**TOTAL**	**20**	**2 808**	**2 778**	**2 128**	**1 778**	**9 512**
50							
51							