HydroMAOC

DEFINITION STUDY

A REGIONAL APPROACH TO IMPROVE HYDROGRAPHIC KNOWLEDGE IN WESTERN AND CENTRAL AFRICA

ENGLISH VERSION

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Introduction

The development of Africa cannot be envisaged without considering its maritime dimension. The continent is surrounded by around 13 million square kilometres of maritime areas under the jurisdiction of African States, including 6.5 million square kilometres of continental shelves. With thirty-eight coastal States out of the fifty-four African States, a large part of African economy relies on maritime accesses, with more than 90 percent of Africa's imports and exports conducted by sea.

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

Although this approach should imply an improved understanding of the maritime environment, unfortunately the African awareness of Blue Economy has failed to address marine knowledge suitably. African coastal States are not yet able to capitalize properly the knowledge related to their marine physical environment -a mandatory milestone to sustainable development- and manage and conserve their African "Blue World". Actually, none of them dispose of sufficient infrastructures to produce their own international nautical charts or manage geospatial information and maritime safety information properly, leaving it to non-African entities lacking of long term strategy for changing this situation. As a matter of fact, the lack of political leverage on that subject is obvious: the International Hydrographic Organization (IHO) in charge of coordinating hydrographic offices and initiating capacity building actions only counts two Member States within its Western and Central African communities.

Two years ago, the IHO agreed to support an initiative for the benefit of Western and Central African Coastal States consisting of developing a regional approach to capacity building. This initiative led to the *HydroMAOC* definition study of 2015, object of the present report, coordinated by the *Service Hydrographique et Océanographique de la Marine* (SHOM – France), in charge of IHO capacity building coordination in the Eastern Atlantic. The scope of this study aims at providing a regional and comprehensive capacity building programme and consistent set of actions to develop hydrography in Western and Central Africa.

The present *HydroMAOC* report provides the main components of this definition study, starting with a SWOT analysis of the capacity building organization in hydrography, then investigating new areas of development for transfer of technology and skills related to Marine Knowledge, before outlining a project proposal aimed at building up a regional, sustainable and robust hydrographic capability.

Context and expectations

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

SWOT analysis: Strengths, Weaknesses, Opportunities, Threats

The SWOT concept

SWOT analysis (acronym of *strengths, weaknesses, opportunities* and *threats*) is a methodology designed to identify and evaluate the aspects of an organization (project, business or situation).
The conception of a SWOT matrix consists of identifying internal and external factors that are favourable or unfavourable to achieve a given objective and sorting them into 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, the elements in the environment that may cause 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 at 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 categories, regardless of their prioritization.

SWOT Analysis		Internal Factors	
		Strengths	Weaknesses
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

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 fundings.	➔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. ➔CB meagre budget	➔ 'Blue World' new concept not fully accepted yet ➔ International organizations reluctant to fund new concepts at the expense of traditional themes, ➔ Poor Governance and lack of integration of Regional bodies (Multiplicity of non-coordinated maritime geospatial data holders).

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

Internal factors of the current CB organization

The leading role of the International Hydrographic Organization (IHO) in hydrographic capacity building 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 services in their mission of providing documentation for the safety of navigation. 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 themes such as hydrographic surveying, International chart regulations and specifications or standards of competence for hydrographic surveyors and marine cartographers. Those standards are the reference within the hydrographic community, be they 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, able to contribute to national maritime infrastructures, amongst coastal States and International bodies.

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. By making it easier to apply to the Organisation, the forthcoming entry into force of the amended IHO Convention in November 2016 should increase the number of members.

As for now, the main argument to apply for IHO membership is the International Convention on the safety of Life at Sea (SOLAS). Under this Convention (Chapter V, Regulation 9), ratified by most African coastal States, contracting nations have the obligation of providing hydrographic services for the safety of navigation. The IMO mandatory audit scheme starting in early 2016 includes the Chapter V obligations in its perimeter, and African Coastal States are amongst the first to be audited.

Capacity building is actually an IHO strategic objective, defined 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"*. To this end, IHO provides guidance to coastal States that require its advices on how to develop a national hydrographic organization, particularly by organising dedicated technical visits on-site. These 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 proposes a path to be followed by coastal States wishing to build a robust national hydrographic capability. Each phase describes a milestone in the development of a hydrographic organization, as detailed in the following table.

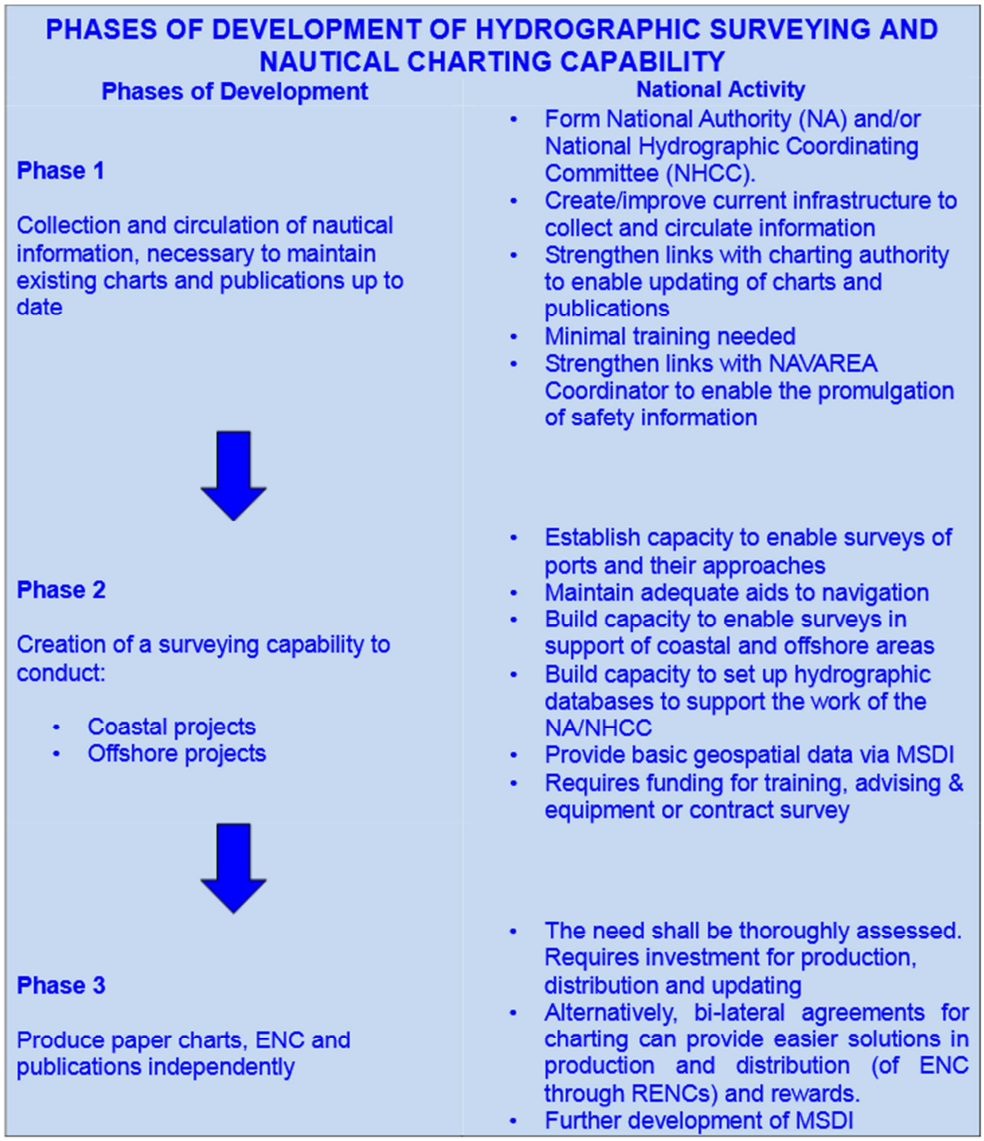

Figure 3: IHO Development phases in hydrography (source: www.iho.int)

In that scope, IHO support the development of hydrography by allocating funds to support capacity building projects schemed in a yearly Capacity Building World Programme (CBWP), striving to match its efforts with those of other International bodies such as the International Maritime Organization (IMO), the Intergovernmental Oceanographic Commission (IOC) or the International Association of Lighthouse Authorities (IALA. The IHO Capacity Building Fund allocated for the year 2016 is in the region of one million euros (EUR), provided in majority by Japan and Korea. Over the 39 capacity building projects schemed in the 2016 CBWP, 25% are technical visits and 70% are focussed on educational projects (workshops, courses or seminars). IHO capacity building actions are prepared and implemented by Regional Hydrographic Commissions (RHC), such as the *Eastern Atlantic Hydrographic Commission* (EAtHC) which covers the coasts of Western and Central Africa.

Due to its tight budget, the IHO current policy is to restrict the benefit of its capacity building programmes on its Member States: Capacity building initiatives towards non- Member States are limited to technical visits and Phase 1 projects. With only 2 IHO Member States out of 19 coastal

States in Western and Central Africa, IHO funded capacity building has limited possibility to support the development of hydrography in this region. As for leverage, the hydrographic unawareness from African decision makers combined challenges the development of hydrography in Western and Central Africa. The SOLAS obligation may be insufficient to entice coastal States to apply for IHO membership. Instead, most of them have their SOLAS obligations handled by foreign States, i.e. France, United Kingdom and Portugal, acting as Primary Charting Authorities (PCA), to provide nautical charting, books and services in the region, consequence of their historical involvement in the area. This passive transfer of responsibility is reflected by the content of the IHO S-11 catalogue of International charts series for the EAtHC region: so far, only one coastal State involved in international chart production, in co-production with one "historical" PCA. Though some hydrographic surveys are executed under the responsibility of coastal States authorities, especially within harbours, after the building of new terminals or dredging, or for specific naval requirements, these surveys are far from fulfiling what is needed for modern, updated nautical charts.

Things might change with the advent of EEZ disputes in the oil-rich Gulf of Guinea. Côte d'Ivoire has already produced a first series of nautical charts in support of its territorial claims. Togo, Benin and the two Congos might follow suite. It remains to be seen that this first effort motivated mainly by maritime delimitations will outlive the International Tribunal of the Law of the Sea's arbitrations.

Therefore, no Western and Central African coastal States is acting independently regarding their own SOLAS obligations on hydrographic services. And the current situation challenges the maintenance and updating of existing charts and publications. To start with, EAtHC African States have difficulties to reach the Phase 1 requirements of the IHO's three-stages strategy: according to the Area Coordinator in charge of collecting and disseminating nautical information within the NAVAREA 2 area, which comprises all EAtHC coastal States, very little nautical information is issued by local services to the Coordinator. More than 40% of EAtHC African States do not have official correspondent or if they have, the latter fails to provide details. Further, existing NAVAREA correspondents are not very responsive, as around 20% only have regular contacts with the Area Coordinator. These figures reflect the fact that EAtHC costal States neither dispose of a national infrastructure nor of an organization able to collect and disseminate nautical information, although they could be eligible to receiving support from the IHO limited to phase 1.

This situation has been endured for 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 of 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 eight EAtHC States (Gabon, Nigeria, Ghana, Mauritania, Senegal, Cabo Verde and Guinea). The mandate of the WAAT was the same for every visit: meeting Government decision-makers and senior officials to emphasize the importance of hydrography and SOLAS requirements, developing and proposing national plans of actions and milestones to meet the host-nation's and international shipping's needs and requirements and advise on measures to improve their national hydrographic capacities. Several following actions were identified by the WAAT after conducting these visits: the first one was to encourage the creation of National Hydrographic

Committees empowered to coordinate the different national authorities and stakeholders in hydrography to make the most of capacity building initiatives, establish survey priorities and look for solutions to collect and disseminate maritime safety information. In 2016, less than 20% of EAtHC African coastal States had formed yet a National Hydrographic Committee (Togo, Ghana and Nigeria). Another subsequent topic raised by the WAAT was education and training, as the Action Team underlined the lack of consolidated regional training opportunities to compensate the high costs of courses overseas. It promoted the idea of training in the region with a connection between regional training centres. Nevertheless, nearly 15 years after, there are not yet consistent hydrographic training opportunities available in Western and Central Africa. The funding issue was also raised by the WAAT, who reckoned that the diversity of GNP from one country to the other could prevent 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 (e.g. port levies on ship calling). The same WAAT also envisaged projects proposals like CACAO[3] and CHARMER[4], but none of these materialised due to the lack of suitable funding sources.

The WAAT experience underlines that capacity building assessments rely on the commitment of three non-African Hydrographic Services assuming de-facto sovereign charting responsibilities in Western and Central Africa. Those European States involvement is driven by the need to maintain up-to-date nautical documentation while facing a significant lack of nautical information and data and a decrease of overseas survey funds. Besides, their bilateral relationship with EAtHC African States is often seen as a poor man's alternative to the IHO strategy towards non-IHO Members when it comes to funding capacity building initiatives. Yet, there is no long-term perspective if this lesser evil solution were to last as national funds dedicated to overseas surveys and bilateral cooperation projects tend to decrease: indeed, most of the shipping routes along the coast of Western and Central Africa were last surveyed during the pre-60's era.

In summary, IHO is the only international organization to provide a technical framework to hydrographic activities and promote their development. However, the fact that its strategy is focussed towards IHO members because of limited capacity building funds leaves EAtHC African States stuck between the difficulty of getting sufficient hydrographic awareness from their national policymakers and the decreasing support from European States.

External factors subject to impact the current Hydrographic CB organization

A closer look into Africa's development current issues and the consideration they are given by the international community highlight the opportunities to be seized in order to promote and develop hydrography in Western and Central Africa.

The 13 million square kilometres of African maritime areas are currently under pressure, with natural resources yet to be fully explored, though they may be illegally exploited, and containing precious marine ecosystems to be protected for a sustainable development of the blue economy.

Those angles of approach are subject to different level of consideration when it comes to hydrographic awareness. The first activities to raise concern on the lack of hydrography in Africa

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

were linked to maritime safety: in 2007, the Ministers responsible of maritime transport attending the first Conference of the African Union Conference agreed on the subject agreed on the urgent need of promoting and supporting national hydrographic infrastructures and capabilities in order to maintain and update hydrographic surveys and navigational products and services. This concern is 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) identifies four main maritime challenges in the region: reinforcing maritime governance, safety and security of the maritime domain, maritime environment management and optimization of ECOWAS maritime economy. In particular, it underlines the fact that poor hydrographic capabilities are a potential cause to pollution and navigation safety hazards. It also points at the lack of capability of coastal States in the region to chart their national Waters, although such a capacity, in the IHO framework of standards is considered as the way forward to improve maritime security and sustainable protection of marine environment. African coastal States are therefore encouraged to consider IHO membership as well as regional co-operation in hydrography to mutualize infrastructures and capacities. The same orientation is mirrored by the 2050 Africa's Integrated Maritime Strategy that identifies four building blocks in capacity building, one of which includes hydrographic infrastructures and facilities. In this perspective, the 2050 AIM Strategy advocates for sub-regional co-operation, capacity-building and co-operation between stakeholders to improve the safety of navigation. And it goes further by promoting capacity-building in the fields of maritime education and scientific research, in which hydrography is also mentioned. Like ECOWAS integrated maritime strategy, the 2050 AIM Strategy relies on the benefit of the IHO Membership opportunity to "provide adequate and timely hydrographic data, products and services and ensure their widest possible use."

This African Union vision of the multiple utility of hydrography would need to be turned into concrete initiatives, as hydrographic expertise and marine knowledge remain focussed on navigational safety. African Union and ECOWAS highlight 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 marine knowledge to ensure economic governance. Indeed, several international organizations can see the true perspectives offered by Blue Economy in the development of certain sectors in the African Waters: For instance, the 1.6 million tons of fish legally captured in West African waters each year represent an estimated wholesale value of US$ 2.5 billion. The African Union has therefore made Blue Economy one of the main items of its Agenda 2063. This major issue has also been addressed by the 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 data gathered by marine research institutions and international organizations is also underlined. Therefore, Blue Economy development has to enhance better the value of a consistent and properly managed marine knowledge.

Marine knowledge, including hydrography, is also critical for maritime governance, including maritime spatial planning, which addresses the framework for managing concurrent uses of a common maritime space. Today, in an interconnected and knowledge-based world, proper maritime

governance is to be guaranteed by consistent and sustainable use of environmental knowledge, including hydrographic data.

Hydrographic knowledge is also indispensable for the management and conservation of marine environment. African maritime strategies mentioned previously already include it and recently, the COP21 acknowledged the critical role of the ocean to address the issues of climate change. COP21 discussions and decisions particularly highlight the multiples challenges the African continent has to face: climate change impact, unsustained infrastructure development, inadequate management of natural habitats and resources and pollution 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 the World Bank, approximately 500,000 people are affected each year in this region by floods and the coastlines of Togo retreat by an average of 5 metres every year.

The 2015 Paris agreement and the visibility thus offered to ocean matters has given the opportunity to start new actions, like the co-operation between the World Bank and France in support of West African countries to reinforce 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 African coastal observatory to improve the knowledge base on coastal erosion, flooding and other climate change disasters along the West African coastal and island nations has been scheduled. The observatory will be part of the West Africa Coastal Areas (WACA) programme launched by the World Bank in 2015. This platform, created in response to requests from several Western African coastal States, aims at helping countries to obtain funding and expertise to manage their coastal areas sustainably. Initiatives of that kind could be of great benefit to hydrography and to maritime geospatial knowledge.

With regard to the last case, regional maritime visions and strategies need to be sustained by proper sets of actions and supported by significant sources of funding. When it comes to the aid to development for the African Continent, the financial leverage is substantial: The European Development Fund (EDF), the main European Union instrument for development co-operation in Africa has been granted EU €30.5 billion for the 2014-2020 period. The World Bank has committed up to US$ 42.5 billion for the year 2015 alone. The African Development Bank (ADB) 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 channel, considering the significant financial fluxes involved. The African Development bank Group framework provides some relatively promising sets of transversal angles for 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, the main objective of which is to 'assist member countries to develop the necessary science and technology-oriented skills to increase economic competitiveness and sustain growth'. To achieve this goal, the bank strategy is willing to support regional centres of excellence as well as infrastructures and training in specific domains, and make sure that trained students can use their new knowledge

accordingly. This holistic and integrated vision could be applied to hydrographic skills in Africa although, as a matter of fact, there is no certified course in hydrography or marine cartography to be found on the African continent. However, Western and Central Africa dispose of well-established regional maritime educational centres, 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 (Côte d'Ivoire). These recognized centres of excellence host regularly IHO funded hydrographic training opportunities but do not dispose of equipment and instructors to operate on their own. Properly endowed, they could obviously be utilised to develop regional 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.

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 may seems to be the main threat as 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 of implementing four different integrated maritime strategies in Western and Central African coastal States. For If we consider maritime safety and security governance, two regional coordination centres 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 (Côte d'Ivoire). According to their respective mandates, they are both entitled to address law-breaking 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 these maritime regional organizations seems necessary to promote the development of hydrographic capacities, the questions of their relevance as seen from higher level of decisions and funding organizations 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 considers 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. This raises awareness of international and regional organizations, particularly when it comes to Blue Economy development and the monitoring of Climate change. Those strategies also encourage capacity building initiatives to be supported by sustained

international partnership and insist on dedicated technology transfer. However, these testimonies of good will do not necessarily imply the availability of dedicated funds to increase capacities in marine knowledge. Indeed, maritime concern remains widely 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 necessity to include hydrographic development projects within major maritime programmes.

Areas of development and ways forward

The SWOT analysis mentioned above addressed the current CB organization in hydrography and emphasised the importance of funding sources. It further underlined the need to identify 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 amongst funders and deciders so that Western African hydrographic capacity building projects could be subject to more political leverage and funding opportunities.

Conservation and sustainably use of the oceans

"Conserve and sustainably use the oceans, seas and marine resources for sustainable development." [5]

With reference to the United Nations' sustainable development goal 14, the future of hydrography should not be bound only to chart production and navigational safety. It now has to stand for the expertise, management and collection of marine geospatial knowledge, for the benefit of all maritime activities and stakeholders. In that perspective, benefits in domains such as Blue Economy, the protection of marine environment and maritime governance need to be emphasized.

Blue Economy development

The theme chosen for the World Hydrography Day 2013 pointed at Hydrography as the basic building block of Blue Economy[6]: "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 to 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 ground for Blue Economy is the fact that 71% of the surface of the globe is covered by seas and oceans, and that 90% of the world trade transit by sea. However, beyond fishing, maritime trade and transit passengers,

[5] United Nations Sustainable Development goals (Goal #14)

[6] https://iho.int/mtg_docs/WHD/2013/Background_Statement_2013.pdf - IHO - World Hydrography Day – underpinning the Blue Economy

[7] www.themaritimealliance.org, based on The Report: State of the US, Ocean and Coastal Economies, 2009.

Blue economy also includes but is not limited to activities such as aquaculture, biomedicine, shipbuilding and very large floating platforms, cables and pipelines, coastal zone management, defence and security, water treatment and desalination, marine recreation and tourism, ocean energy and minerals, ocean science and observation, port operations, robotics and submarines, shoreline development, telecommunications, weather and climatology, etc..

The importance of an efficient and sustainable usage of the sea is supported by economic facts. First of all, considering tables of carrying capacity against draught marks for most ships, 30cm extra depth of navigable water allows at least 2,000 tonnes more cargo to be carried. According to the Cruise Line Industry Association, cruise ship passengers spend at least $100 each for each day ashore, which represents over a daily quarter of a million dollars income from a typical cruise ship for every day in a port. As for the United Nations Food and Agricultural Organization, more than 15% of animal protein is provided by oceans for about 3 billion people: in that sector, only fishing industry representing livelihood provision to more than 540 million people and aquaculture (farming) of fish and aquatic plants is worth more than $106 billion. In the telecommunication sector, over 95% of the world's intercontinental data and telephone traffic transit by undersea cables, and the proper and safe routing of cables depend on hydrography[8]. In the energy sector, the progress of cost competitiveness of offshore wind farms compared to fossil fuel and nuclear sources is now well established[9]; the planning and installation of MRE require a detailed hydrographic knowledge of the concerned areas. In the port industry sector, 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[10].

Marine environment protection and climate change

Relevant and accurate marine geospatial knowledge is especially needed in coastal areas, where a 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 the world population live within 60km of the sea, and this figure is likely to attain 75% in 2025.

Coastal areas are amongst the most threatened by the effects of climate change: sea level rises, storm 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 erosion and sea level rise deeply affects the coastline physical characteristics on the long term.

West African coastal areas face a range of challenges: coastal erosion, overexploitation of natural resources (such as fisheries), marine and coastal pollution, rapid urbanization, unsustainable land use. These aspects, combined with a weak environmental governance in place, needs to be improved.

Preventing these kinds of environmental threats requires first an accurate set of reference data of coastal areas. Nowadays, datasets already acquired by all stakeholders are not sufficient to produce

[8] Submarine Cables and the Oceans – Connecting the World. UNEP-WCMC, 2009
[9] Green Economy in a Blue World-Synthesis Report; UNEP and others, 2012
[10] Moretti E, "Local Multipliers", American Economic Review, May 2012

a common marine environmental picture of Western African coastal areas that could be properly used to face and address current and future environmental challenges in that region. Such a reference picture could be exploited to support many applications: oil spill simulations, wave and storm surge modelling, environmental impact studies, implementing maritime highways and recommended routes to secure maritime traffic, etc.

Towards a Knowledge-based Maritime governance

"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".[11]

Yet, a durable way to address those economic and environmental challenges starts by building the set of environmental data mentioned above.

Such a common environment database will meet most marine information requirements. The main principle is the multiple uses of collected data, based on the 'collect once, use many times' principle initiated by the Maritime Affairs Department of the European Commission. The information needed for coastal zone management concerns many different fields: such as coastal protection, shipping, fisheries, spatial planning and ecology. The information needed for coastal management is of crucial importance in the choice of type of survey and data processing as well as the quality of data. Another important driver is the local conditions that show large differences between different sections of Western and Central African coasts.

For improving coastal management, regional governance needs to take maritime challenges very seriously. As a matter of fact, existing nautical charts covering Western and Central Africa are all produced by non-African States organizations. Few EAtHC coastal States have either a national Hydrographic Office or a national Hydrographic Commission to address these challenges. This lack of structure makes dialogue even more difficult when it comes to address national/regional awareness on the importance of hydrography. The example of Maritime safety information (MSI) which operates in theory within an already consolidated Worldwide Navigational Warning Service (WWNWS) speaks volume: because of the weak MSI structure often reduced to port authorities, no MSI information or only a few is being issued by Western African coastal States. In 2016, only 17 MSI messages were sent to the NAVAREA 2 area coordinator by West and Central African States. The same paucity affects the NAVTEX service in the NAVAREA 2 region (see next figure), which does not provide coverage below the Las Palmas station (purple colour). Navigational warnings are therefore disseminated via SafetyNET[12] (on a circular area corresponding to the Dakar service area) by the NAVAREA 2 Coordinator (France).

[11] International Hydrographic organization – 2013 World hydrography day background statement.
[12] www.iho.int/mtg_docs/com_wg/CPRNW/WWNWS_Publications_&_Documents/English/SafetyNET.pdf

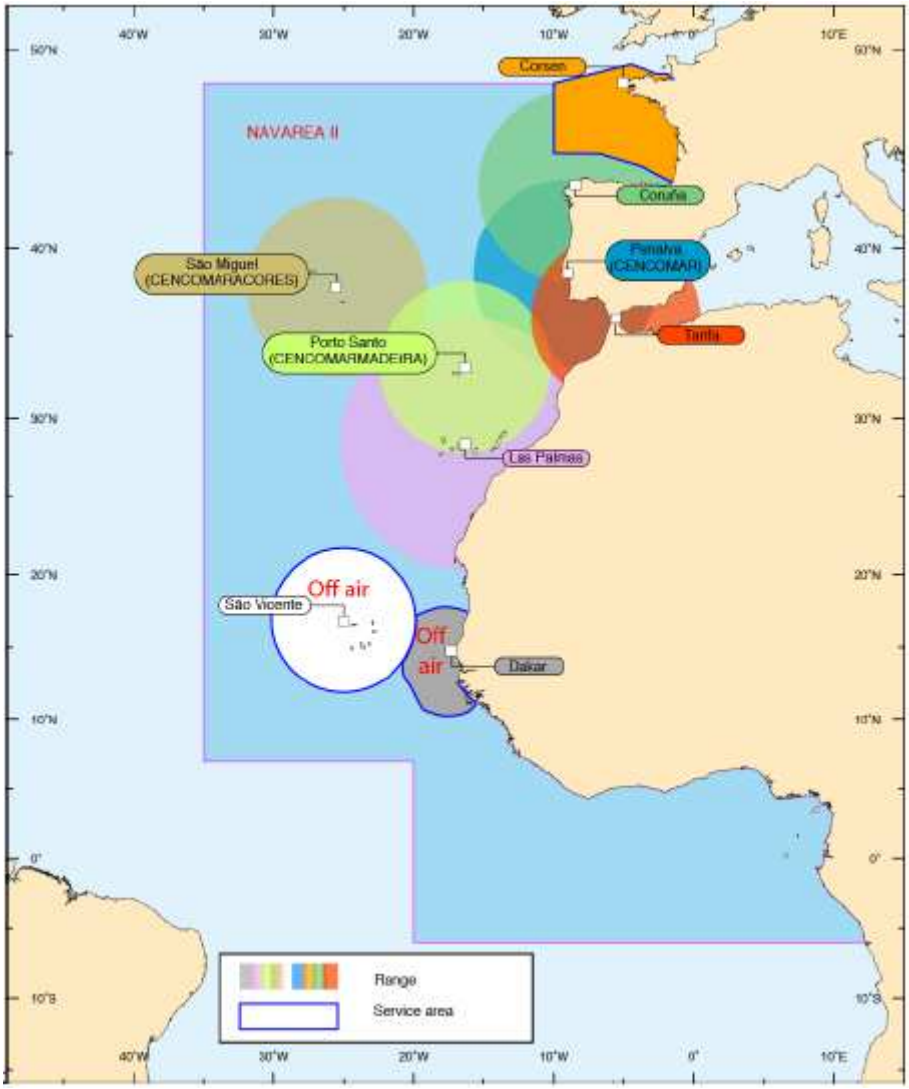

Figure 4 : current NAVTEX service coverage within the NAVAREA 2 area[13] (2016 NAVAREA 2 self-assessment report).

As for marine geospatial data collection and management, a sustainable setup to address maritime challenges is crucial to conduct hydrographic activities in line with international regulations and standards and maintain a comprehensive regional marine environmental picture. First of all, maritime and littoral governance should need framework documentation and infrastructure to schedule and harmonize their activities.

In that scope, setting up a regional hydrographic programme could be an important milestone prior to implementing a regional capability together with a sustainable marine environmental picture.

Hydrography and Education

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 is no locally based training capability available in that region. Long distances between certified trainers mostly based in the USA

[13] Dakar NAVTEX station is not operational since Mars 2012; Cabo Verde NAVTEX station is off air since 2013

and Europe and local trainees increase training costs and therefore reduce 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 co-operation, considered as another alternative, tend to be rare nowadays, and industry stakeholders' initiatives remain closely linked to the acquisition equipment.

The limited resources (funds and trainers) made available by the IHO's Capacity Building Fund to develop hydrographic capabilities imply consolidated management and drastic choices of Work Programmes to balance the CB budget and reduce logistic costs. Once a need is expressed by one coastal State to the regional Coordinator, the time elapsed between the expression of need, the funding of an appropriated course and the nomination of a candidate can be prohibitive. Candidate selection also tends to be challenging as mechanisms to follow-up the applicants' training history and professional background and guarantee 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, is either to fund an overseas training course themselves or to purchase hydrographic equipment and include a training package provided from the contracted company.

Nowadays, the growing demand for training is constrained by 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 (specialised in tides, currents, maritime boundaries or coastal hazards), marine GIS developer, MSI manager. All those maritime specialists would contribute to the Marine geospatial data capitalization and provide services to support the development of Blue Economy, management of Marine environment and safety of populations in the maritime and littoral domains.

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 would duplicate, in a much poorer way, a face-to-face training course through digital contents. The E-learning approach actually takes into account the student environment, if 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:

- Theoretical 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 by 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, include them in existing educational programmes and 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 rationalizing academic contents, improving access to specific educational resources and supervising 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 French-speaking countries is to be achieved by the end of 2016.

To be fully effective, a distance learning courses requires appointing qualified tutors to assist the students throughout the timeline and the different modules of the online course. The tutor's role slightly differs from the one of a regular teacher but is not 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, webinars, forums, etc.

As for a blended learning capability, it implies to be able to perform onsite practical sessions. As underlined previously, some specific technical skills need to be reasonably well acquired through face-to-face sessions and experiences, otherwise the interest of educational programmes 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 attractive cost. For instance, the estimated cost of a MSI E-learning guided session is estimated to be only 20% of that of a 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 (Côte 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. These academies could actually host a hydrographic department with a set of survey acquisition and data processing equipment to provide hydrographic training courses. Indeed, the theoretical content of such local courses would be based on e-learning material, allowing local trainers to comply with IHO updated and validated educational contents. Such local training capabilities would reduce the cost of onsite practical sessions and be better adapted to coastal State's needs. The academies could also act as regional experts to provide coastal states with technical guidance and even achieve surveys for third parties.

Information and Communication technologies (ICTs)

Role of ICTs

In this sector, maritime geospatial data applications must be improved, and rely on recent advances in Information and communication technologies (ICTs), particularly in Geospatial Infrastructure Solutions 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.[14]

Marine Spatial Data Infrastructures (MSDI)

In that sector, regional marine special data infrastructures (MSDI) should ideally be used to address the needs of as many legitimate stakeholders as possible. Some layers that should be provided via MSDI contain relevant information on the maritime and littoral domain. Developing ICTs tools related to marine environment and maritime activities could help partly automatize and prioritise the data acquisition and repositories, which can be a tedious task, considering the lack of local expertise and the number of end-users: national maritime authorities, other national ministries, regional bodies, private companies, foreign hydrographic offices, etc. Therefore, addressing in the same time customers' needs and data collection processes should optimise the design of the GIS tools and their MSDI subcomponents. Data stored with these two considerations in mind should facilitate both the stakeholders' access to data and specific products.

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

The use of geomatics engineering in the maritime sector could save efforts, monies and human resources, avoid data being collected twice and ensure multiple uses of products for various purposes. A major outcome would consist of developing a regional maritime geospatial information web portal, together with the creation of an infrastructure to host and manage the data. Such infrastructure should be able to aggregate layers based upon data collected by various Western and Central African partners and provide relevant web services and community tools to coastal managers. Open access to these layers would facilitate the dissemination of marine geospatial information and products to the community of users: collaborative cartographic tools, nautical information feedback services, vertical & horizontal datums conversion applications and communication tools (chat, shared space, forums, etc).

Marine Geospatial data acquisition

Several techniques can 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). There is no such thing as 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, maritime delimitations, 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.

EO (Earth Observation) techniques have become a relevant asset in raising awareness and access to marine geospatial knowledge in a cost-efficient approach. Satellites are now able to collect relevant environmental information thanks to better processing methods of imagery and remote sensor datasets. Among these techniques, satellite derived bathymetry (SDB) is able to validate depth information by processing water colour pixels from satellite imagery. SDB technics have actually been exploited for 30 years by SHOM, 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 by water depth (up the “Secchi depth”, rarely more than 20 metres), due to the penetration of light in the water column. Nowadays, thanks to physics-based inversion models, the depth/accuracy ratio has been improved and if well-controlled, precisions can attain 10 metres or less horizontally and up to 10% of the depth. When the bottom is not visible, these techniques are restricted to satellite topography, i.e. the extraction of objects such as coastline, shoals and aids to navigation (buoys, lighthouse, etc.).

In this perspective, an SDB assessment over the ROI (region of interest) is a mandatory step towards confirming the validity of SDB techniques considering the local water column properties.

Building a sustainable regional hydrographic capability

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

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:

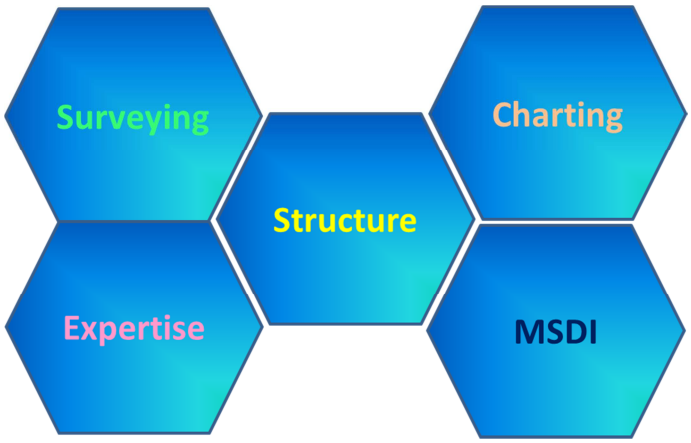

Figure 5 : Main functions of a hydrographic capability.

- 'Surveying' is the function dealing with data collection in order to get the best description of the marine environment.
- 'Charting' is the one dedicated to nautical charts and the production of books.
- 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 aims at facilitating and coordinating exchanges and sharing of maritime geospatial data and services to stakeholders at different levels of the community of users.
- The 'Structure' component has to do with the coordination and the management of all the previous components.

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 should 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 institutional materials (instructions, policy documents, organization chart and technical procedures) needed to establish hydrographic capabilities effectively 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 due to 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 6 : the 'E' implementation components.

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

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

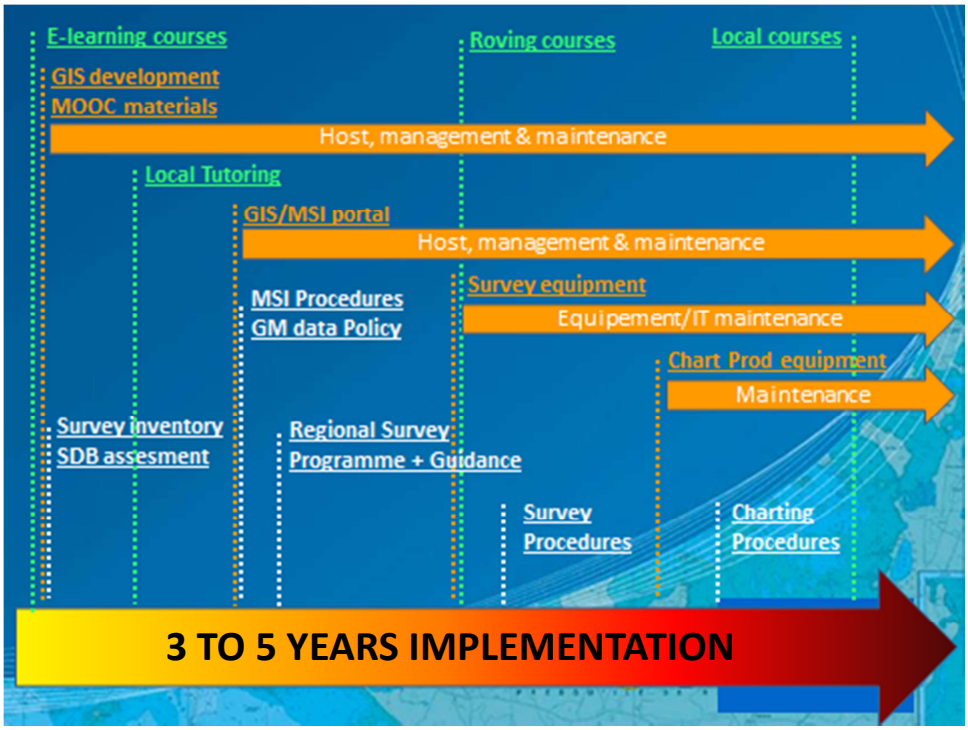

Figure 7 : Regional Hydrographic capability – Implementation timeline

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

Education

Indeed, all core functions detailed in the previous section require properly trained personnel. This component encompasses all educational components, from basic training to skill maintenance:

- The 'surveying' function requires properly trained personnel in various fields: hydrography to conduct surveys, electronics and mechanic to operate and maintain survey equipment (echosounders, current profilers, GPS devices, etc.) and 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, produce and update charts and IT to deal with the 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 lawyers and administrative personnel to deal properly with hydrography and maritime geospatial data management within the maritime governance.

Most of support skills courses (IT, electronics, mechanics and administration) can be acquired off-the-shelf. But when it comes to hydrography in particular, most of the courses needed 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 consist of developing 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-time courses, tailored to acquire or maintain skills related to hydrography. In this perspective, a list of potential MOOCs topics has been drafted against the duration of distance learning, which takes 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 access to multiple stakeholders involved in the Western African maritime development. Then, another block of more technical MOOC resources is to be further developed to support the delivery of IHO certificates 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 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 institutes in Western Africa, designing a marine cartography course dedicated to land cartographers could be cost and time effective 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 French or Portuguese-speakers.

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.

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-effective and profile-raising to seek out partnership with existing MOOC platform, such as the IMarEST's Marine Learning Alliance[15] or the CIDCO's distance learning platform[16]. 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[17] of the "Intergovernmental Oceanographic Commission" (IOC). The 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 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 echosounders, side scan sonars, GPS receivers, inertial motion sensors, sound velocity profilers, 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 to provide 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,
- 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.

[15] https://www.mla-uk.com/
[16] http://cidcomoodle.ca/moodle28/
[17] http://www.oceanteacher.org

The provision of such equipment will have to be phased with the training sessions, so that recipients can practice their skills, and future local trainers can be fully operative to ensure the whole spectra of hydrographic training is covered. Moreover, maintenance framework and support would have to be included to provide 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 have to be implemented from the maritime spatial data infrastructure:

- datum-converter tool to edit the vertical datum of your bathymetric data,
- tide prediction built-in tool,
- 3-D current visualization tool,
- real-time maritime traffic flux visualization tool,
- external data import tool to visualize information layers from other sources,
- a dynamic cartographic environment to allow users to create their own maps by taking benefit from the portal's data and built-in edition tools and to share them online with other users for further collaborative applications,
- an online nautical information feedback service, allowing maritime stakeholders - be they be general public, port authorities or private companies- to report 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 on SHOM's maritime geospatial data portal. The purpose was to gather various sets of maritime spatial data over Western Africa together and to compare this 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 African maritime portal could be, based on off-the-shelf technologies and datasets.

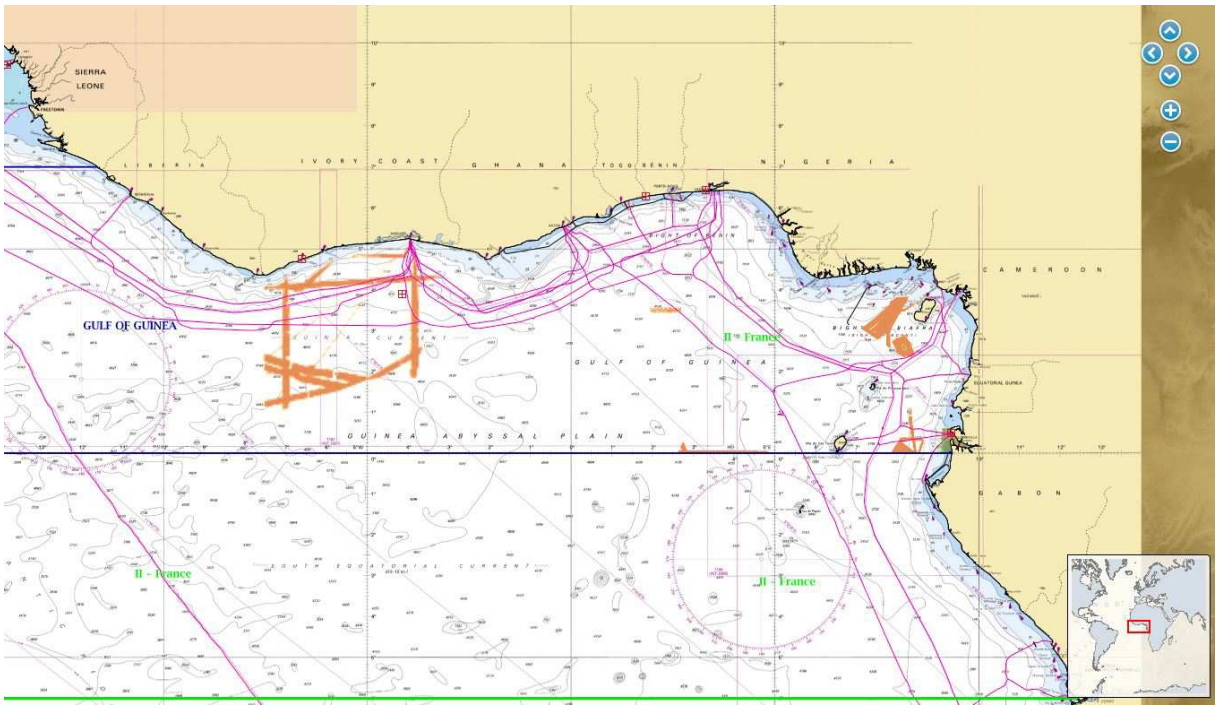

Figure 8 : Map area from Western and Central Africa GIS model

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 (laws, engagement letters, contracts) 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 domains. This task would be composed of three phases: first gather all data collecting experience in the region and evaluate the

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

To begin with, successful harmonization of different data acquisition technics requires the definition of goals and instruments, along with information on instruments integration and accuracies. It also means integrating each level of data for the different areas. At the same time it also refers to the integration of the terrestrial and marine components of the ROI, 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 to map and monitor the physical and environmental parameters.

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 colour) and Sampling (sediments). All the gathered survey experiences will then be analysed and summarized by date, geographical area, coverage, purpose, operating conditions, details of contract and techniques used and results in a final report. The result will be a report listing and summarizing past experiences and a set of geo-referenced data layers synthetizing the 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 the literature, the partners in-situ experience and the available information on the environmental condition of the coastal site. It will further indicate the most suitable survey techniques against their products and costs. 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 of products and instrument during the survey to reduce mobilization and demobilization time. In the end, a consolidated regional hydrographic programme based on these algorithms, priorities and cross-examination should be generated.

Risk analysis

The different options chosen to implement this regional hydrographic capability and the risk analysis are presented in the following section.

Funding opportunities

The overall cost of that regional hydrographic capability through this implementation plan is in the region of € 10 million. The implementation plan has been designed for a five years period. The breakdown costs and detailed action plan are tabled at the annex.

In addition to the implementation of a regional capability, it is necessary to apportion funds to create the initial marine geospatial database. Therefore, another € 5 million should be earmarked to cover these activities, provided that EAtHC coastal States gradually take over the data collection to maintain the dataset and expertise needed to support the Blue Economy, the Maritime Governance and the protection of the Environment.
Besides, economic studies have shown that the cost/benefit ratio for national investment in hydrography and nautical charting is always positive and could exceed 1:10[18].
However, 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 proposal expounded in this report remains a draft project.
Therefore, to reduce that risk, the main option would be to integrate the project into a larger maritime/environmental/climate development programme. This requires establishing a relationship with International funding organizations to get an overview of their projects pipes and then, try to blend the hydrographic awareness into a broader perspective.
For instance, the ADB funding policy includes fiduciary funds dedicated to environmental and climate change. Regional Projects opportunities could be included in that research scope, relying on coastal States with significant awareness on hydrography in the Western and Central African region.
As for the World Bank, the recent implementation of the West Africa Coastal Areas Program (WACA) which consists of strengthening coastal risk management should offer opportunities to invest in Blue Economy. This program targets most of the Western African coastal States, i.e. the Republics of Benin, Cabo Verde, Cote d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Senegal, Sierra Leone and Togo, the Islamic Republics of Mauritania and Gambia, the Federal Republic of Nigeria and the Democratic Republic of Sao Tome and Principe. Such a significant regional programme could be a promising opportunity to include some of the hydrographic concepts and solution that have been discussed.

Another option would be to lobby those International funding organizations in order to integrate the 'Blue World' concept as a specific transverse sector, after having made then realise that marine renewable energies, maritime spatial planning, action of the state at sea and Blue economy are all based on a common geospatial knowledge.

The educational approach

As for the education component, the risks identified are the inconsistency of the learning approach, the reliability of the economic model and the sustainability of local tutors and trainers networks. With regards to the first risk, the IHO has funded an e-learning experimentation project in 2016 to provide hydrographic guidance and good practices. Moreover, the e-learning implementation is focussed on the pedagogic approach and processes rather than on pure computer assisted training. This blended approach mixes distance learning phases with face-to-face practical workshops. The use

[18] 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

of a specific pedagogical approach combining e-learning resources, continuous assessment methodology and high expectations from the students should eventually improve the course efficiency.

The second risk related to educational economic model 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 and 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 to non-IHO members, other 'non-hydrography related' administrations or private sector stakeholders, even if this means having fees to pay. Besides, onsite regional capabilities in charge of practical sessions and skill maintenance could provide regional expertise and perform surveys for coastal States. This could become a potential source of income whilst contributing to maintain the capability and equipment.

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

Equipment and infrastructure sustainability

The main risk identified in this paragraph is the sustainability of regional infrastructures and equipment pools. As for the survey equipment, priority must be given to simple, easy-to-use and deployable technologies to take advantage of the nautical means available to the recipients. The development of e-learning material must focus on the use of freeware solutions as long as they fulfil 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 material and infrastructures, support from existing maritime academies is crucial to raise the profile of hydrographic training and ensure consolidated technology and skills transfer I n the Western African region.

Conclusion - Perspectives

The multiple contributions of hydrography to the development of maritime and coastal areas need no longer to be listed. They must be embodied in large scale investment programmes. The necessity of building a hydrographic capacity over Western Africa is even greater today, as Blue Economy and environmental awareness arises. This definition study aimed at linking past hydrographic capacity building experiences with the current 'Blue' challenges faced by the EAtHC region.

In this perspective, the achievement of such a definition study for the Western and Central African region is to be considered as the first milestone towards the implementation of a regional hydrographic capability. However, until sufficient funds are allocated, support and assistance to the EAtHC region needs to be encouraged, using the existing IHO capacity building framework and keeping in line with the broader developments envisaged in this study. The EAtHC capacity building work plan already complies with this concept and developments of e-learning material have already been funded by the IHO to further the experimentation.

In the meantime, the outcomes of the hydroMAOC study will be used to foster the implementation of hydrography in large scale maritime and coastal programmes. Relevant contacts are to be maintained or initiated by high level visits and the organisation of events. Liaising with international funding agencies is also a main objective to stress the importance of maritime and coastal challenges, starting with marine geospatial knowledge. This next step has yet to be done.

ANNEX: BREAKDOWN OF COSTS

HydroMAOC study follow-up	2017
High level visits to funding agencies and stakeholders	15 000
E-learning material development (survey specifications)	30 000
Subtotal	45 000

Project Mamagement	Y1	Y2	Y3	Y4	Y5	Total line
Project Manager	70	70	70	70	70	350
project Coordinators (education, equipment, empowerment)	150	150	150	150	150	750
Training team	150	150	150	150	150	750
Subtotal	370	370	370	370	370	1 850

Education implementation	Y1	Y2	Y3	Y4	Y5	Total line
distance learning guided sessions		20	20	20	20	80
training for trainers + mentoring		25	25			50
training for tutors (e-learning) + mentoring	25	25				50
hydrographic survey roving courses (blended courses)			300	300	300	900
nautical cartography roving courses (blended courses)				300	300	600
side expertise roving courses (blended e-learning courses)		50	50	50	50	200
implementation of regional training centres (assistance)		50	50	50	50	200
6 :"face-to-face" courses Certified CAT B training in hydrography				600	150	750
7 :"face-to-face" Certified CAT B training in nautical charting				600	150	750
Subtotal	25	170	445	1 920	1 020	3 580

Equipment implementation	Y1	Y2	Y3	Y4	Y5	Total line
E-learning materials development (MOOC)	300	100	100	10	10	520
Deployable survey equipment pool (5 States/year)		300	300	300	300	1 200
NAVTEX station deployement (1 station per year)		400	400	400	400	1 600
Charting production equipment (5 States/year)				200	200	400
Regional Marine GIS Web portal + service development		300	150	150	150	750
Marine Spatial Data Infrastructure Implementation		150	50	50	50	300
Expertise tools and equipment (software, machines, etc)		50	30	10	10	100
Equipment maintenance and support		100	100	100	100	400
Subtotal	300	1 400	1 130	1 220	1 220	5 270

Empowerment implementation	Y1	Y2	Y3	Y4	Y5	Total line
Survey prioritization analysis	50					50
Regional hydrographic programme		50				50
Regional Maritime geospatial data policy draw up		20				20
Framework document draw up (surveying, charting, expertise, MSDI, structure)	20	20	20	20	20	100
High level visits / audits	10	10	10	10	10	50
Subtotal	70	90	20	20	20	220

TOTAL COST	765	2 030	1 965	3 530	2 630	10 920