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SEABED WARFARE STRATEGY



REPORT BY THE WORKING GROUP

FEBRUARY 2022



The seabed holds many secrets. From the mysterious lost city of Atlantis to tales of sea monsters, it has inspired legends for centuries; from the first ocean explorations in the 19th century to discoveries of abyssal fauna, it has continually amazed the scientific community. In 2022, our knowledge of the seabed – which covers two thirds of our planet – is still limited and much less extensive than our knowledge of near space.

However, although the seabed still remains a mystery in many regards, we are well aware that it is becoming a new playing field of strategic competition. The Strategic Review requested by the French President in

2017 and its 2021 update have brought to light the tensions arising, and the intricate links between logics of might and fait accompli policies.

The ocean depths are like a new frontier, where ambiguous and hybrid strategies are staged. It goes beyond the diversity of public and private economic projects in the fields of energy and mineral, gas and oil mining, it is about the ambition to control the new communication routes. Submarine cables, which convey almost all internet traffic, are particularly coveted : in the summer 2021, an oceanographic vessel was again spotted off the coast of Ireland, operating near cables that connect Europe to the United States.

This competition is prompting States and private companies to pursue new ambitions. With the second-largest Exclusive Economic Zone (EEZ) in the world, France cannot remain standing on the shore, watching from a distance what is taking place in this field of action. Rather, we have to act.

To protect our interests and guarantee freedom of action for our armed forces, and to seize opportunities to support our strategic autonomy, we are developing a seabed warfare strategy. Similar to what we did for cyber and space, this strategy takes advantage of technological and industrial opportunities as well as cooperation with our closest partners to monitor and act on, from and towards the seabed.

The French President has made the seabed one of the ten strategic goals of the «France 2030» roadmap, and the Ministry for the Armed Forces intends to contribute fully to this national ambition. Daring, innovation and the firm commitment of our entire defence community will be our best assets to make seabed warfare an area of excellence for France.

Florence Parly



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EXECUTIVE SUMMARY

After long being a capability only pioneering nations like France and certain military powers possessed, a growing number of players are now able to reach the seabed, spurred on, in particular, by the offshore drilling, energy and distribution sectors and the booming submarine communications cable industry. An analysis of the various activities taking place at the bottom of the seas – whether military, economic or scientific – brings to light a growing desire to control this area, with ambitions that sometimes align but can also conflict.

France has long-standing expertise in submarine operations and underwater action. However, the dynamics and determination displayed by certain strategic competitors in deep sea action, together with the emergence of new technologies in submarine robotics, on-board energy and artificial intelligence, are leading us to review our approach to the importance of the seabed in our defence strategy.

The «France 2030» investment plan consolidates the nation's ambition for the seabed, yet it is time to be prepared to meet the challenges inherent in this increasingly disputed area. This is the aim of this Ministerial strategy which, working on the premise that conflicts have now effectively extended to the seabed, offers an ambition on a par with the stakes, and a related roadmap.

The seabed is a discontinuous and complex environment that is hostile to man and difficult to reach. It therefore remains largely unknown; less than one fifth of the topography of the sea floor is determined with precision and more than three quarters of the seabed are located at depths of more than 3,000 metres, where the pressure exceeds 300 times that of the surface atmosphere. Similarly, according to the classifications established by the United Nations Convention on the Law of the Sea (UNCLOS), the legal status of the seabed is not uniform and a particular place is reserved for the International Seabed Area – the «Area» – defined as common heritage of mankind. Lastly, being the scene of both civil and military activities, this area also appears propitious for deploying hybrid strategies, with difficulties detecting and attributing actions.

Government and private activities are developing on the seabed, be it oil and gas extraction, the submarine cable market, or deep-sea exploration for the exploitation of mineral resources. These multiform activities come with increasingly advanced technological innovations, with a booming submarine drone and robot market. At the same time, major strategic competitors are stepping up their ambitions in this area.

In a context in which the great powers game, fait accompli policies and a desire to harness resources are increasingly interlinked, the freedom of action of our armed forces and the protection of our interests could henceforth be in jeopardy, thus calling for a renewed stated ambition.

Meeting these different challenges requires a strong national ambition to guarantee our freedom of action and strengthen our strategic autonomy by taking advantage of the technological, industrial and related cooperation opportunities.

Faced with diverse, evolving and dual modes of action, guaranteeing freedom of action for our armed forces above all means extending control of the maritime space to the seabed. We must demonstrate our determination to develop knowledge, monitor and take action. These three activities will primarily be pursued in the territorial waters, the French Exclusive Economic Zone (EEZ) and any area of operational relevance. Within this framework, it will be necessary to increase our capabilities for surveillance and action down to a depth of 6,000 metres. Efforts should particularly focus on improving our knowledge of the undersea environment, and on expanding our information and action capabilities to deep waters and disputed environments. Lastly, our strategy should be consolidated by a legal position aligned with international law, while adapting the domestic legal framework to future issues.



Controlling the seabed should also allow us to consolidate our strategic autonomy by seizing technological, industrial and cooperation opportunities that arise in this new field. In this respect, advantage must be taken of technological breakthroughs in autonomous underwater and remotely operated vehicles. This focus will be supported by actions designed to encourage and guide the development of a French Defence Technological and Industrial Base (DTIB) capable of meeting the needs. Likewise, targeted cooperation initiatives with some of our closest partners will bolster our ability to rise to these strategic challenges.

This ambition translates into a roadmap aiming to set guidelines and support our ability to control the seabed, from the perspective of operational efficiency and requirements.

The first stream of this roadmap focuses on fully integrating the seabed topic into our defence strategy, which implies clarifying the nature of the related operations. Defined as all operations conducted towards, from and on the seabed and involving systems capable of operating on their own or within a network, seabed warfare operations will be structured around three functions: developing knowledge, monitoring and taking action, with a range of uses including hydro-oceanographic operations, surveillance missions and undersea interventions and actions. In this regard, the doctrine will be clarified as the process of integrating seabed warfare into the current doctrinal corpus is pursued. Similarly, the intelligence services of the French Armed Forces Ministry will provide support in anticipating and analysing threats to France's national interests and the armed forces' freedom of action, according to specific policies.

The second stream defines the related governance. Overall management will be overseen by the working group created to draft this Ministerial strategy. Organised around key stakeholders, such as the Defence Staff (EMA), Naval Staff (EMM), Directorate General for International Relations and Strategy (DGRIS), Defence Procurement Agency (DGA), Directorate for Legal Affairs (DAJ), Defence Innovation Agency (AID), Directorate for the Protection of Defence Installations, Means and Activities (DPID), the French Hydrographic and Oceanographic Office (SHOM) and the intelligence services, this committee will continue to lead several working groups focusing on the six pillars of DOTMPF¹. Entities and organisations outside the ministry could be involved depending on the subject. The results of this work will be presented annually at ministerial level. Finally, the French navy will set up a dedicated structure under a coordinating authority to meet both visibility and coherence objectives.

The third stream aims to prepare the capabilities required to pursue the stated ambitions. It includes work to achieve consistency with existing or future arms programmes and operations that are also stakeholders in seabed warfare (CHOF [Hydrographic and Oceanographic Capabilities of the Future] and SLAMF [Maritime Mine Counter Measures of the Future]), as well as the development of new capabilities. A capability development process will be conducted along two lines, starting with obtaining an exploratory capability, followed by incremental capability building with a view to implementing by 2025, the first AUV and ROV that can operate down to 6,000 metres.

The fourth stream seeks to consolidate expertise in seabed warfare to guarantee achievement of the stated ambition. It will consist in identifying the necessary human resources, generating specialists through appropriate training and career pathways, but also creating emulation through chosen partnerships. The creation of a pole of excellence in seabed will help to stimulate development in this new field, through cross-fertilisation of expertise and know-how in a dual military and civil field geared to innovation.

In full integration with the work already carried out in an interagency context, this Ministerial seabed warfare strategy thus displays a renewed ambition.

In a context of re-emerging strategic competition, it aims to give our armed forces, directorates and services full control over an area that is set to be a key strategic issue.

¹ Doctrine, Organisation, Human Resources, Equipment, Support, Training

RECOMMENDATIONS

THE AMBITION TO CONTROL THE SEABED TO PROTECT OUR STRATEGIC INTERESTS	
R2-1	Support innovation in the development of sensors on board deep-sea AUV and ROV.
R2-2	Accelerate studies on physical variables for the detection of submarine installations.
R2-3	Study the particular modes of ultra-low frequency acoustic propagation.
R2-4	Increase our undersea search, surveillance and intervention capabilities to meet the needs inherent in maintaining freedom of action for our forces in areas with depths down to 6,000 metres.
R2-5	Continue to analyse ways of deploying underwater surveillance vehicles in order to broaden the range of military options: air-portability, combat ships, submarines, etc.
R2-6	Make CEPHISMER a centre of expertise capable of implementing a military capability complementary to SLAMF for depths greater than 300 metres.
R2-7	Complete the project to revise national regulations on the laying of submarine cables (system of authorisation in the territorial sea and of notice in the EEZ).
R2-8	Integrate the supervision of "autonomous vessel/maritime drone" activities into the regulations for State representatives at sea.
R2-9	In an order issued by the French Prime Minister, define the areas within the protection of national defence interests for the purpose of marine scientific research.
R2-10	Support DTIB development in command of sensitive capabilities, by taking advantage of solutions developed for civil needs and in line with the France 2030 plan.



ROADMAP	
R3-1	Pursue the process of integrating seabed warfare into the doctrine.
R3-2	Maintain the ministerial working group created to draft this strategy and, as required, include other organisations and ministries contributing to seabed warfare. It will oversee the topic from the DOTMPF perspective, with the aim of achieving visibility, efficiency and overall coherence. It will report yearly to the ministry.
R3-3	Define the human resources needed for the proposed ambitions in the short and medium term, for undersea search and action. This will require mapping existing skills, to initiate a viable skills-generation process tailored to requirements.
R3-4	Accurately assess existing skills and identify possible recruitment and training sources to define career paths adapted to the implementation of new capabilities required by seabed warfare: implementation and maintenance of autonomous and remotely operated underwater vehicles, saturation diving, detailed knowledge of the undersea environment, underwater detection in the ultra-low frequency range, mass data processing and management.
R3-5	Identify and select partners in research, education and industry that are willing to create a national "deep seabed" pole of excellence, and implement it.

1 THE SEABED AND STRATEGIC COMPETITION

The principle of freedom of the seas long prevailed until their territorialisation became necessary in the second half of the 20th century. And this process of appropriation also applies to the seabed, for both economic and geopolitical reasons. As emphasised in the Strategic Update 2021, the “seabed is [...] increasingly becoming the setting for power struggles.”² Growing interest in the seabed and its singular nature propitious to the development of discreet, or even hybrid, modes of actions, call for efforts to master all kinds of seabed activities in order to safeguard our interests or the freedom of action of our armed forces.

1.1 The seabed : a complex and potentially disputed environment

1.1.1 A Heterogeneous and still Unknown Realm

1.1.1.1 Significant Physical Discontinuities

With a surface area of some 361 million square kilometres and an average depth of 3,800 metres³, the seabed can be divided into two main categories: the continental margins, which include the slope and the shelf (extending from a few kilometres to several hundred kilometres from the coast depending on the region) and the ocean basins where the floors are very deep.

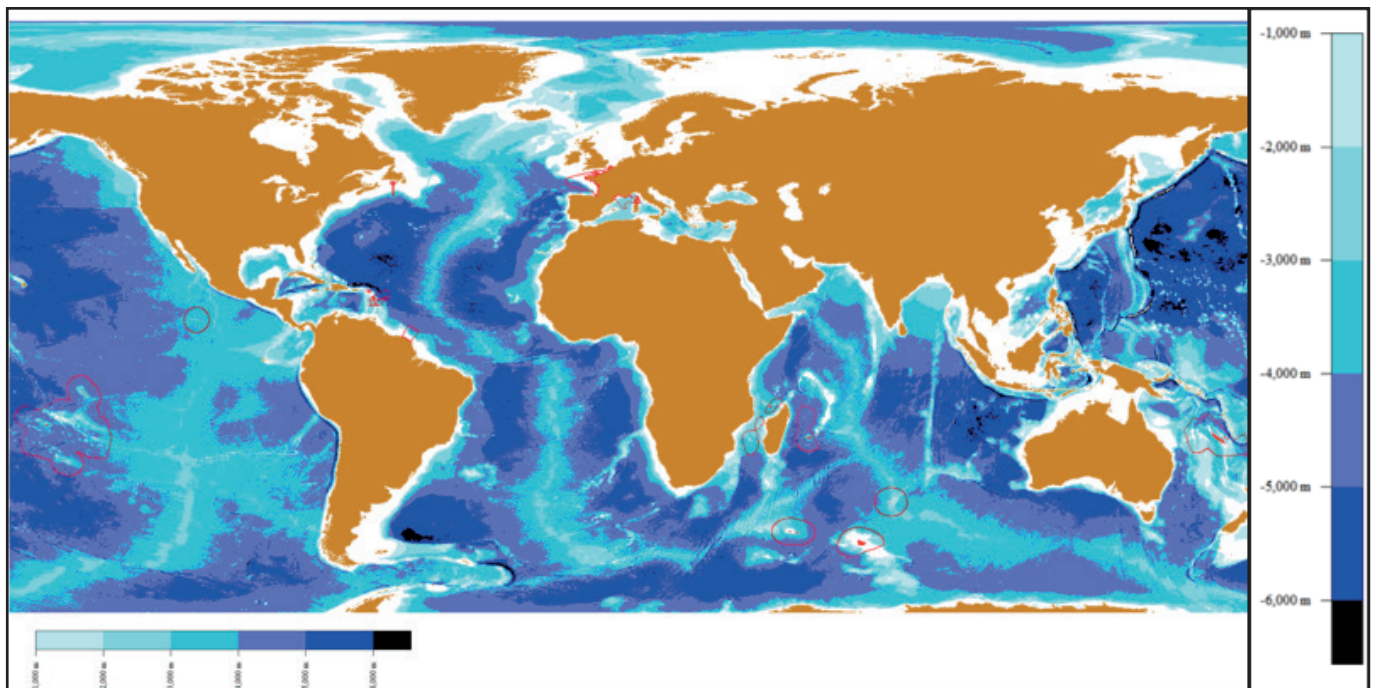


Figure 1 - Bathymetry Overview

² Actualisation Stratégique 2021 – DGRIS – DICOd – Bureau des Editions – January 2021

³ 75% of the seabed is more than 3,000 m deep.

This underwater area features considerable bathymetric diversity and significant environmental discontinuities.

The abyssal plains can reach depths of 5,000 to 6,000 metres, the deepest point being in the Pacific Ocean, at approximately 11,000 metres below sea level, at the Mariana Trench. Ridges (mountain ranges) rise up 2,000 to 2,500 metres above the plains. These meandering ridges interspersed with faults, contribute to the expansion of the oceanic crusts and are the site of intense telluric activity (underwater earthquakes and volcanism). Their top part most often features rifts, i.e. deep, narrow valleys (1 to 2 km deep and 20 to 30 km wide on average).

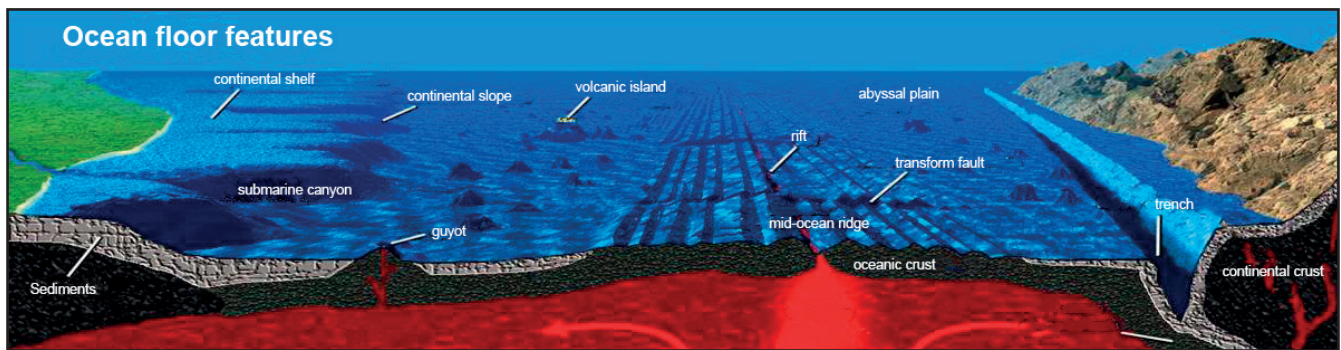


Figure 2 – Description of Underwater Features

On either side of the axis of the ridges, over several hundred kilometres, basaltic rocks practically outcrop, with very little or no sedimentary cover. Away from the ridges, only elevations such as volcanoes and seamounts have rocky outcrops. Outside these zones, deep-sea sediments are almost exclusively composed of fine particles (detrital clay and organic fragments from the fall of suspended particles), the coarsest elements consisting of volcanic debris, polymetallic nodules and boulders dropped by glaciers during the melting period.

The continental shelves are covered with sediments dating back to the last glacial cycle, scattered and re-distributed by the swell and currents. The muddy sediments are in this case reduced to low energy areas.

1.1.1.2 Incomplete geophysical knowledge

The seabed is still quite unknown: barely 20% of the topography has been accurately measured with an echosounder – even only once – and only 2% of the seabed is known with metric precision⁴.

While satellite altimetry observations¹⁵ can be used to map large areas of underwater reliefs, the horizontal resolution obtained is of about several kilometres. Similarly, owing to the limited capacity of optical and/or laser observation systems on board space and airborne vehicles to measure underwater relief beyond a few dozen metres below the surface, knowledge of the bathymetry of the deep seabed is mainly gained using multibeam echosounders deployed from maritime vehicles (specialised vessels, drones, etc.), with the accuracy of the measurement depending on the carrier's immersion.

Finally, knowledge of geophysical parameters related to the seabed (nature of the seabed, hydrology, marine currents, optical and acoustic properties, magnetic and gravity fields, etc.) is still incomplete as it depends greatly on in situ data collection.

⁴ <https://www.mdpi.com/2076-3263/8/2/63/html>

⁵ Measurement of surface ripples from underwater landforms

1.1.2 The Legal Status of the Seabed has become an International Issue

The United Nations Convention on the Law of the Sea (UNCLOS) of 10 December 1982, segments maritime spaces according to distance from the coast and the morphology of the seabed: most of the rights and prerogatives of coastal states relate to the territorial sea (up to 12 nautical miles from the coast) and the exclusive economic zone (up to 200 miles). In some cases, an extension of the continental shelf may be granted based on geophysical conditions (up to 350 miles). Beyond these segmentations lies the international seabed area (commonly known as «the Area») - the common heritage of mankind, covered by the high seas.

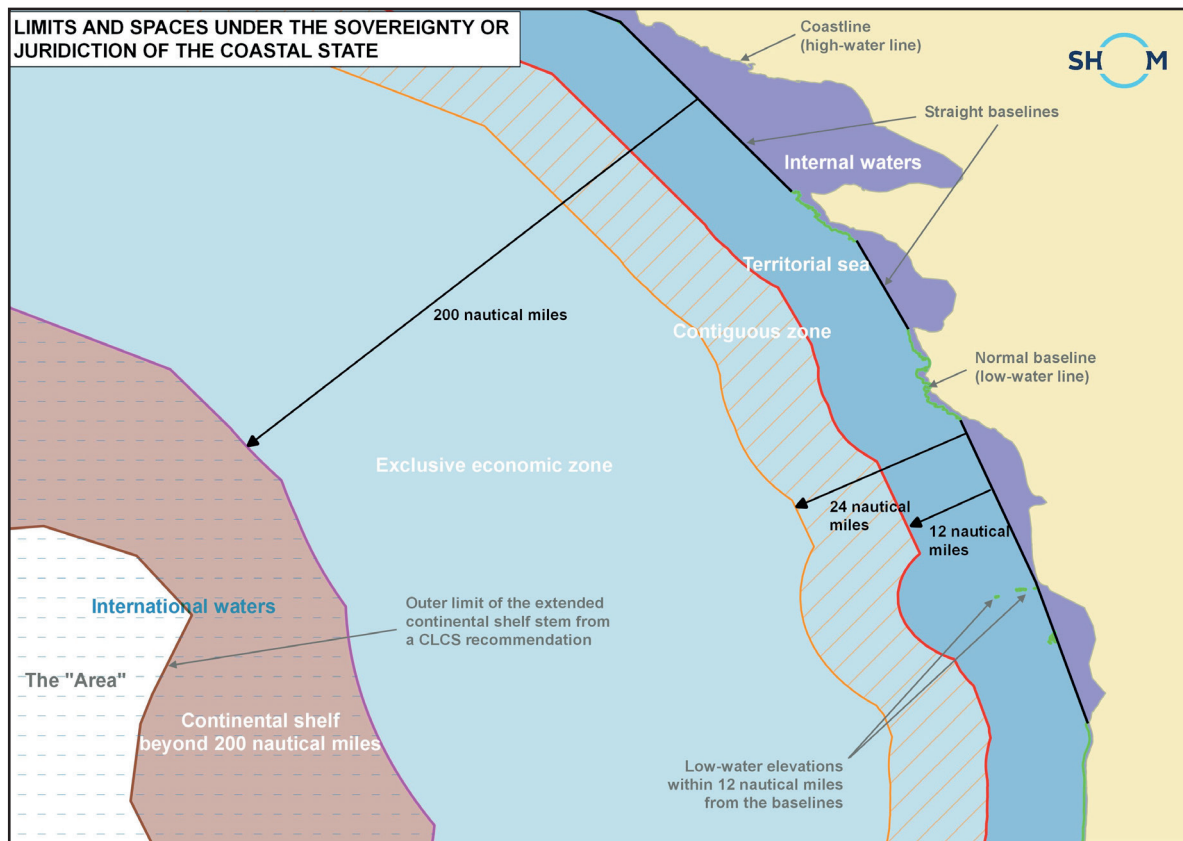


Figure 3 – Segmentation of the Maritime Space

1.1.2.1 UNCLOS protects the Interests of Coastal States

In the territorial sea, UNCLOS allows a coastal State to regulate the use of the seabed. Any activity undertaken on the seafloor or in the subsoil of the territorial sea, such as laying submarine cables, conducting marine scientific research (MSR) or hydrographic surveys, must be granted prior authorisation in domestic law.

Furthermore, while UNCLOS requires the right of innocent passage to be guaranteed to foreign vessels, without any prior authorisation or notice needed, it may be suspended, under certain conditions, for reasons vital to security in certain zones determined by the coastal State. In addition, although it may not exercise its jurisdiction over a foreign warship, the coastal State⁶ may require the vessel to leave its territorial waters if it fails to comply with its laws and regulations⁷. Lastly, some acts are incompatible with the right of innocent passage, particularly collecting information to the prejudice of the defence or security of the coastal State as well as research or hydrographic surveys, and more generally any other activity that has no direct bearing on passage.



The situation is different in the Exclusive Economic Zone (EEZ). The UN Convention recognises sovereign rights for the coastal State to explore and exploit the seabed and subsoil for economic purposes and to conserve and manage natural resources. The coastal State's jurisdiction is also recognised with regard to marine scientific research (MSR) and the establishment and use of artificial islands, installations and structures. But these rights are limited to "reasonable" protection measures concerning the laying or maintenance of submarine cables or pipelines by other States. More broadly, the latter enjoy freedom of navigation, overflight and the laying of submarine cables and pipelines, as well as "other internationally lawful uses of the sea related to these freedoms"⁶.

Finally, the international seabed area has a particular status intended to protect this common heritage of mankind⁹. Therefore, activities carried out in this space must be conducted for the "benefit of mankind"¹⁰ exclusively for peaceful purposes. The exploration and possible exploitation of the Area remain subject to authorisation by the International Seabed Authority (ISBA).

1.2 State and Economic Activities Developing on the Seabed

1.2.1 Diverse Activities

According to the OECD, the ocean economy should increase from \$1,500 billion currently to \$3,000 billion by 2030. It will concern several activities in connection with the seabed, namely oil and gas exploration and extraction, use of submarine cables for fibre optic communication or distribution of power produced at sea, and finally mining which, although still in its infancy, has a high potential in theory.

On average, deep sea discoveries accounted for half the conventional oil and gas volumes discovered over the last decade. Although offshore exploration has considerably declined since 2014¹¹, the extent of offshore reserves discovered and the estimated amounts of technically retrievable resources offer significant possibilities for production growth. The stability of these operations, which was called into question during the shale oil boom in the USA, depends on fluctuations in the price of energy materials that define the breakeven points¹². Today, therefore, many analysts expect to see offshore production shift from developed to developing countries.

The future of deep-sea mining is currently torn between two contradicting trends: protecting biodiversity in the ocean depths and the contribution of certain mineral resources to the development of clean energy and the fight against global warming. Therefore, on the one hand, advocates of ocean floor environmental preservation are trying to establish a moratorium via the ISBA on exploitable areas outside State EEZs, but there is no consensus on their estimates in the scientific community. On the other hand, greenhouse gas reduction targets and the necessary energy transition will generate considerable needs for minerals such as magnesium, cobalt¹³, nickel and rare earths that are particularly used to produce batteries. The thousands of polymetallic nodules as well as the polymetallic sulphides and cobalt-rich crusts found at the bottom of the sea bear these essential resources and the Clarion-Clipperton Zone (CCZ) – stretching from Mexico to Hawaii –, is alone estimated to contain six times more cobalt and three times more nickel than all the onshore reserves worldwide. Increased pressure

⁶ Article 19, UNCLOS

⁷ Article 30, UNCLOS

⁸ Article 58, UNCLOS

⁹ Article 133 *et seq.*, UNCLOS

¹⁰ Article 130, UNCLOS

¹¹ The number of active offshore rigs dropped from an average of 320 in 2013 and 2014 to around 220 at the end of 2016 and has remained at this level ever since

¹² In 2020, the break-even point of a barrel was \$46. The offshore production cost of a barrel dropped by 16% between 2018 and 2020

¹³ Cobalt production should increase by 500% by 2050 to meet the needs of battery industry

on onshore deposits, geopolitical tensions affecting global supply chains, and the socio-economic risks associated with certain production areas are all arguments that could eventually weigh in favour of seabed mining, whereas certain legal hurdles could soon cease to apply¹⁴. Conversely, limitations in terms of technology and profitability may extend the status quo in this environment¹⁵. At the end of 2021, thirty-one exploration contracts had been issued by the ISBA to governments, public organisations and private companies. Finally, in this context, several studies have been conducted to identify the potential impacts on ecosystems of extracting minerals in deep waters¹⁶. Although they demonstrate recognition of environmental issues and negotiations are under way to develop a protective legal framework¹⁷, a global approach to balance these two trends will undoubtedly be pursued.

In submarine communications, 99% of global digital data transit via fibre optic cables laid on the sea and ocean floors. While they were previously installed and used by leading telecommunications operators, new players, including GAFAM, are moving into this sector and developing new projects¹⁸. Today, these cables are one of the lifelines of the world's economic system and their impairment, even temporary, could have major impacts on the economies of the countries concerned. Submarine cables are not limited solely to communications and also concern the transport of energy, i.e. offshore wind power¹⁹ or tidal power.

Lastly, the development of maritime tourism is a growth factor of various human activities liable to take place on the seabed, particularly via the development of an industry linked to submarine tourism vehicles.

1.2.2 A Field of Technology largely driven by Business and Research Activities

The autonomous underwater vehicle market was estimated at €1.5 billion in 2021 and should reach €4.3 billion by 2026, i.e. an annual increase of more than 20% over the period. Such developments can but increase the human activities conducted on the seabed. Similarly, the possibilities brought by autonomous tools for measuring and mapping the ocean floors could revolutionise scientific knowledge and foster the expansion of economic activities in this environment.

The submarine systems market is today primarily dominated by American stakeholders (40%)²⁰, followed by Europeans²¹ (33%), with several entities posting revenue in excess of three billion dollars. Over a third (35%) of European companies in the sector are British²² and develop complementary activities across almost all submarine technology segments. Germany is the second largest pool of European players²³. Japanese players are the leaders in Asia²⁵, accounting for 7% of global players.

¹⁴ This mining could start earlier than expected since the microstate of Nauru triggered the «two-year rule» in July 2021. This rule requires the ISBA to establish a legal framework within two years, after which time the mining may begin, without regard for the legal framework adopted.

¹⁵ Some major technological difficulties remain, particularly in terms of bringing the ore up to the supply vessel.

¹⁶ Cf. Stratégie nationale d'exploration et d'exploitation des ressources minérales dans les grands fonds marins (Report by Jean-Louis Levet to the French Secretariat-General for the Sea, July 2020).

¹⁷ In particular, negotiations could lead to the recognition and establishment of Marine Protected Areas (MPA) in the high seas already promoted by France.

¹⁸ For example the MAREA cable linking the US to Spain which belongs to Facebook, Microsoft and Telxius and Google's DUNANT cable linking France to the US.

¹⁹ The market should move into the commercialisation stage within five years with four kinds of floating wind turbine technologies

²⁰ Including Lockheed Martin, General Dynamics, Huntington Ingalls, Video Ray, Teledyne, Oceaneering L3Harris.

²¹ ECA, Kongsberg, Saab, Saipem, Technip FMC, BAE Systems, Deepocean.

²² Including Aleron Subsea, Msubs, AAE Technologies, Soil Machine Dynamics, SMD.

²³ TKMS, Evo Logics.

²⁴ Including Mitsubishi Heavy Industries, Tsurumi Seiki, Kawasaki Heavy Industries, IHI Corporation.

²⁵ Including the leader Jamstec in particular.



Meanwhile, the sonobuoy market is dominated by historical British and American actors.

Chinese and US research institutes and universities account for 51% of listed research entities and are mostly in the top ten. The three leaders are the Academy of Sciences (China), the Massachusetts Institute of Technology (US) and the Woods Hole Oceanographic Institution (US). The proportion of Google Scholar publications by Chinese and US entities represents 76% of the entities' top ten publications.

The high number of Google Scholar publications by Chinese research entities in the Top 10 focusing on submarine technologies (78,000 out of 220,090 publications) reflects real interest in research on the seabed topic. The second Chinese university in the ranking is the NorthWestern Polytechnical University (NWPV), an institution referenced as a key player which has close ties with the Chinese People's Liberation Army.

1.3 In a Context of renewed Strategic Competition, the Seabed Extends the Competitive Arena

1.3.1 Issue addressed by key competitors

A demonstration of the potentially disputed nature of the seabed would not be complete without looking at the ambitions and programmes of the major military powers, namely the USA, Russia and China. They reflect sharp awareness of how fundamental controlling this space actually is.

Seabed warfare begins in the sovereign area. Starting in the 1950s, the United States deployed fixed submarine detection networks (Sound Surveillance Systems, SOSUS) along their coastline, but also at different strategic points in order to prevent the penetration of Soviet submarines and to keep watch over it. At the same time, the Soviet Union developed fixed systems. China, whose submarine forces have been fast-expanding, are also investing in studies of the submarine environment.

Each of these three parties are developing programmes that will allow them to develop and enhance their orders of battle and eventually have a substantial panel of seabed surveillance and action capabilities.

Countries with submarine forces have also long had dual-purpose units in order to develop knowledge of the underwater environment that is vital for safe navigation, especially in shallow waters. They are scientific vessels – specialised in oceanographic and hydrographic research – some of which are equipped with multibeam echosounders²⁶, as well as ROVs²⁷ and AUVs²⁸.

The Russian, Chinese and US naval forces also have ships capable of laying submarine cables and conducting underwater operations.

Russia

Russia is very active in everything relating to underwater combat. Seabed warfare is an integral part of Russia's naval strategy with a particular focus on submarine detection and the use of AUVs.

²⁶ Type of sonar used to map the seabed.

²⁷ Remotely Operated Underwater Vehicle.

²⁸ AUV: Autonomous Underwater Vehicle. Unmanned Underwater Vehicle (UUV) is another name, which encompasses AUVs and gliders.

Established back in 1965, the Main Directorate of Deep-Sea Research (GUGI²⁹) is directly linked to the Russian Defence Staff. It brings together all seabed investigation and actions assets down to a depth of 7,000 metres and implements a comprehensive panel of systems including intervention submarines operating from other "carrier" submarines, hydrographic and oceanographic vessels, as well as manned mini-submarines, AUVs and ROVs.

Moscow has invested in the renewal and extension of the GUGI's resources, beyond its sole scientific requirements and in a context of economic constraints.

Looking forward, Russia is counting on the development of heavy AUVs to carry out specific underwater missions, primarily in the new maritime spaces in the Far North. Fuel cell or nuclear propulsion systems will allow AUVs to navigate for over a month.

Finally, in March 2018, President Putin announced the development of the Poseidon system, a nuclear torpedo with the autonomy of an AUV and carrying a nuclear warhead. This programme makes Russia the first nation to develop next-generation weapons capable of navigating at great depths and over a long distance (10,000 km claimed). This project was unveiled to the public in July 2018.

China

China has been developing projects that demonstrate its interest in harnessing the seabed for military purposes. It has been investing heavily in maritime scientific research through an ocean data collection programme with the aim of extracting natural resources and supporting the development of military naval capabilities and maritime diplomacy.

Since March 2018, the Ministry of Natural Resources (MNR) and the Chinese Academy of Sciences (CAS) have become key stakeholders in China's offshore oceanographic research. Thanks to extensive investments, the number of vessels and the tempo of their activities have constantly increased. These entities have their own sensors and are believed to be capable of implementing manned intervention submarines, as well as ROVs, AUVs and gliders.

China also owns a geological survey fleet designed to explore seabed resources in claimed areas.

Since 2015, China has been testing a major submarine detection network project called "Underwater Great Wall". It is a network of submarine surveillance and intelligence infrastructure.

Regarding deep sea research and intervention, Chinese naval robotics is fast expanding. By 2025, China plans to acquire a fleet of civil AUVs capable of exploring the seabeds and collecting scientific data. In 2019, the first Chinese heavy AUV HSU-001 were presented during a military parade.

USA

The United States have solid experience in operations conducted on and from the seabed. The historical SOSUS (Sound Surveillance System), the US network of passive hydrophones designed to detect submarine and ships, particularly provided quality acoustic information about Soviet naval activities³⁰.

The US Navy implements a fleet of two cable layers and six oceanographic vessels. They all feature powerful multibeam echosounders and can implement AUVs capable of operating down to 6,000 metres (Hugin-6000 and Remus-6000) and a combination of ROVs that can reach 4,000 metres (Hercules and Sea Horse) and 6,000 metres (CURV-21).

²⁹ GUGI: Glavnoye Oupravleniye Gloubokovodnykh Issledovaniy.

³⁰ SOSUS not only strengthened the immunity of the US undersea deterrence, but also allowed the United States to regain the upper hand over the Soviet SSBNs, that originally operated near the American coasts.



The growing competition with Russia, which has been upscaling in the field of seabed warfare, and China that has been investing massively in this area, has prompted the United States to renew their efforts. The US Navy is therefore upgrading its acoustic detection SOSUS, now renamed Integrated Undersea Sound System (IUSS)³¹. Simultaneously, with the support of DARPA³², it is developing several projects with the aim of :

- being equipped with a complete range of AUVs, compatible with existing or future carriers³³;
- improving the range and endurance of AUVs with fixed submarine stations designed for their energy recharging, communications and data transfers (Forward Deployed Energy and Communications Outpost - FDECO);
- designing autonomous systems networks that are rapidly projectable and configurable (Advanced Undersea Warfare System - AUWS), or encapsulated fixed payload systems, capable of deploying decoys, weapons and communication nodes (Modular Undersea Effectors System - MUSE).

1.3.2 Emergence of New Ambitions

1.3.2.1 United Kingdom

There has been marked interest in seabed warfare for several years, particularly for the purpose of submarine cable security. In 2006, a first report titled "An overview of the submarine cable technology" addressed the issue of Britain's resilience in this area. It was followed by a parliamentary debate in 2018 that led the country to adopt national legal protective measures, including the monitoring of military property and equipment that could damage cables³⁴.

In a context of increasing operational activity, particularly in the Atlantic theatre of operations and in the North Sea, the Royal Navy is seeking to develop autonomous underwater systems to improve its performances in anti-submarine warfare, mine warfare and seabed warfare³⁵.

The Integrated Review, published in March 2021, confirmed the attention paid to seabed warfare, with the stated aim of developing the capability to monitor submarine communication cables and underwater areas, with a specialised vessel and underwater drones.

1.3.2.2 Australia

Australia developed awareness of submarine cable security early on, no doubt due to its insularity and historical isolation from major submarine cable routes, which tend to pass via the Malacca Strait to link Europe and the Indian Ocean to Asia. It is particularly one of the first countries to have published studies on the economic importance of these cables and the need for better protection, both in the national framework and at a regional level, as part of Asia-Pacific Economic Cooperation (APEC). The nation is also seeking to establish itself as a key platform in the region, encouraging in particular the arrival of cables to its country and adopting a specific resilience model. Today, the country has nine submarine lines (eight regional and one international), and four new projects in the pipeline³⁶.

³¹ IUSS is a scale-up of the SOSUS. It particularly includes listening devices projectable in a theatre of operations.

³² DARPA: Defense Advanced Research Projects Agency – a Department of Defense agency responsible for the research and development of new technologies for military use.

³³ Several programmes are in progress particularly for medium-sized AUVs called MUUV (Medium Unmanned Underwater Vehicle) designed for both mine warfare missions and environmental data collection. Programmes with a view to developing large multi-mission AUVs having an extensive range are also receiving significant financial support (XLUUV Echo Voyager/Orca for example - XLUUV: Extra-large unmanned underwater vehicles)

³⁴ PhD Thesis «L'Etat et le réseau mondial de câble sous-marin de communication» by Camille Morel – 18/11/2020.

³⁵ Final report no. 119/FRS/DGA2019/Ligne 14 of 18/08/2020 «Emploi opérationnel et intérêt capacitaire des véhicules sous-marins « autonomes » à travers le monde et verrous technologiques éventuels associés».

³⁶ PhD Thesis «L'Etat et le réseau mondial de câble sous-marin de communication» by Camille Morel – 18/11/2020.

Australia gave an unequivocal answer to the recent proposals by China, particularly when it refused the operator Huawei in 2019 for the laying of a new cable on its national territory. It has also set up specific maritime protection zones or “corridors” at its two main cable entry points (Perth and Sydney), with the aim of limiting competing activities and ensuring the integrity of the cables serving its territory. Concerned about the rise of China in the Pacific, Australia is strengthening its marine area surveillance capabilities. It is aiming for a drone-based mine warfare capability and is closely scrutinising Chinese submarine cable plans.

1.3.2.3 India

Historically positioned on one of the most frequently used submarine cable communication routes, India is a major hub in this area, which warrants close attention to the question of seabed warfare. Capability-building efforts particularly focus on developing unmanned high-endurance platforms designed for both mine warfare and undersea operations or seabed mapping³⁷.

1.3.2.4 Japan

As an important economic centre, Japan is a preferred landing point of transpacific communications links. While it suffers both demographic and economic competition from its large neighbour China, it is still one of the world’s best-equipped countries in terms of cable connection. The country is also taking part in the Arctic Connect project initiated by Finland, which aims to link Japan to Northern Europe via the Northeast passage³⁸. Lastly, the Japanese submarine Shinkai 6500 is one of the four submarines in the world to achieve performances equivalent to French IFREMER’s Nautilie, and particularly to descend to a depth of 6,000 metres³⁹.

1.3.3 An Increasingly Disputed Area

1.3.3.1 An Area Propitious for Hybrid Strategies

The seabed has several points in common with outer space and cyber space.

Firstly, activities are developing at the bottom of the sea in dual civil and military mode. Just like New Space, the advent of a New Seabed, boosted by the growing extraction needs of the oil and gas industry, cannot be ruled out. In response to the major investments of the leading military powers in the Arctic, the Mediterranean or the China Sea, intense economic and scientific activity is rapidly developing. Stimulated by heightened research, the cohabitation of military and civil players is fast developing, particularly in the field of cables, which illustrates this ambivalence between civil players and strategic, or even military, stakes.

Second, the seabed gains by technological breakthroughs, which speed up its conquest and disrupt the legal framework. As in outer and cyber space, they alter the perception and intensify the complexity of the man-machine relationship. In this context, although several technological limitations have long restricted the development of AUV, particularly in the fields of communication and endurance⁴⁰, many projects illustrate the rapid development of autonomous underwater systems. Although this trend provides the opportunity to develop a submarine capability at low cost, it requires both cutting-edge operational expertise and ethical thinking about the possible use of lethal force without human supervision.

³⁷ Final report no. 119/FRS/DGA2019/Ligne 14 of 18/08/2020 «Emploi opérationnel et intérêt capacitaire des véhicules sous-marins « autonomes » à travers le monde et verrous technologiques éventuels associés».

³⁸ PhD Thesis «L’Etat et le réseau mondial de câble sous-marin de communication» by Camille Morel – 18/11/2020.

³⁹ Réflexions sur le Seabed Warfare – Lieutenant-Commander Anthony Auger-Ottavi – 2020.

⁴⁰ Of the many technical issues inherent in implementing autonomous underwater systems (navigation range, decision-making autonomy, component maintenance and reliability, etc.), communication on the one hand (between manned and unmanned systems, and between autonomous systems themselves), and endurance on the other (power generation and storage) are definitely the most critical. («Emploi opérationnel et intérêt capacitaire des véhicules sous-marins autonomes à travers le monde et verrous technologiques éventuellement associés.» Final Report no. 119/FRS/DGA2019/Ligne 14 of 18 August 2020.).



This question, which has already been addressed as part of the AI strategy for the Ministry for the Armed Forces, has also been studied since 2017 by a governmental expert group (GEG) within the Convention on Certain Conventional Weapons (CCWC).

Lastly, despite the scientific breakthroughs, the seabed is nonetheless immense and opaque, and can therefore only be accessed and used by holders of state-of-the-art technologies. It is an uninhabited environment that is difficult to keep watch over, still largely unknown and totally beyond the knowledge of the general public. The nature of this environment and the lack of available resources to monitor it therefore encourage dissimulation and render any act difficult to characterise. Given the features of the environment, hybrid strategies can emerge, combining secret commercial, scientific and military activities that may or may not be attributable.

1.3.3.2 Grammar of "Submarine Hybridity"

Due to its nature and intrinsic features, the seabed gives rise to a new grammar of strategy linked to a certain form of "submarine hybridity".

Ambiguity, first of all, stems here from both the difficulty of keeping an immense, unknown, opaque and barely accessible submarine area under surveillance, and the complexity, heightened by the exercise of a right that is still too weak and shaken up.

The notion of thresholds, secondly, is difficult to comprehend due to the difficulty perceiving an action, which complicates control of a **possible escalation**. Although there is practically no risk of losing human lives in such a theatre of operations, which is uninhabited in essence and highly robotised, the opacity of the seabed carries the risk of unrestrained actions being undertaken by automated systems that are difficult to control due to the nature of the environment⁴¹.

1.4 The Protection of our Strategic Interests and Freedom of Action of our Armed Forces could be in Jeopardy

1.4.1 Multiple Threats to Strategic Submarine Installations

1.4.1.1 Submarine Telecommunications Cables

Issues at Stake

Some 450 submarine communications cables currently in operation convey around 99% of intercontinental digital data exchanges. This infrastructure constitutes the accessible physical layer of cyberspace, the main vulnerability being sensitivity to damage caused by nature or humans. Fifty-one of these international cables in operation land on French national territory, with twenty-seven in metropolitan France and twenty-four in overseas French territories. In this regard, the connectivity of overseas territories⁴² is of strategic importance for France.

⁴¹ In the submarine area, particularly in very deep waters, it is very difficult to reconcile range, security and speed of communication. This complicates vehicle guidance and information exchanges, unless umbilicals are used, as in the case of ROV (Remotely Operating Vehicle).

⁴² Source SGDSN.

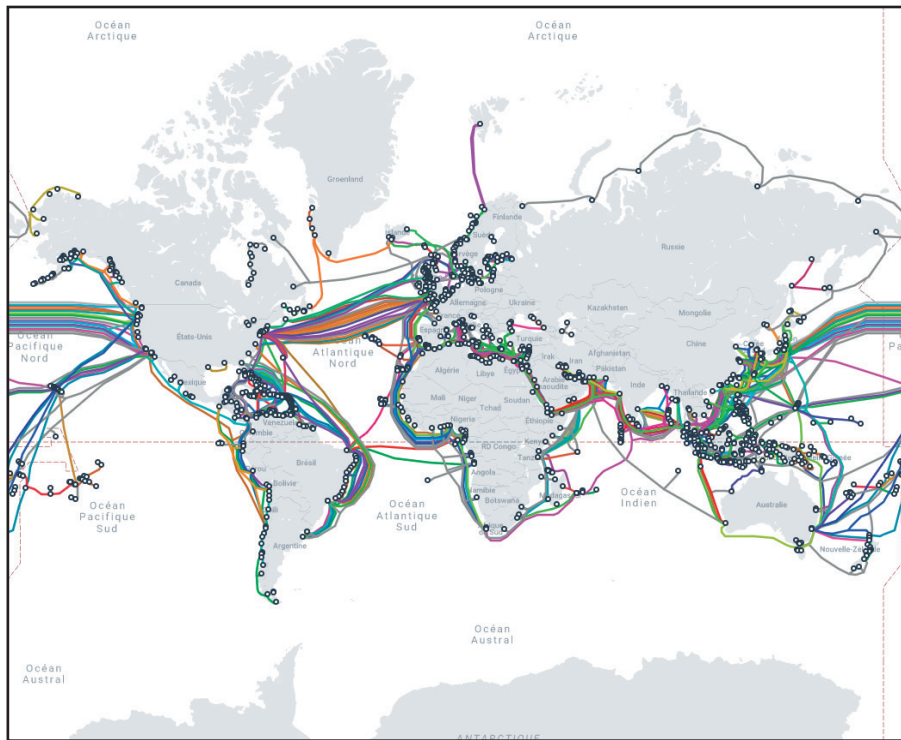


Figure 4 – Intercontinental Communication Cables⁴³

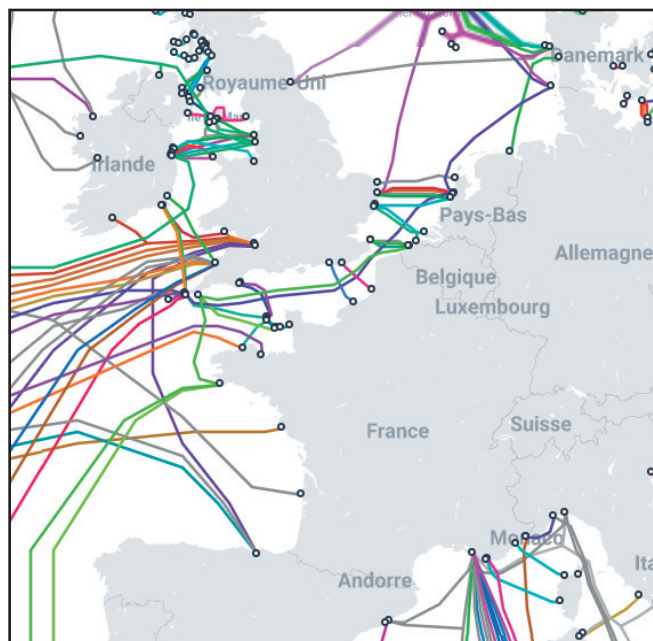


Figure 5 - Internet Communications Cables – Metropolitan Territory⁴⁴

⁴³ <https://www.submarinecablemap.com/#/>

⁴⁴ <https://www.submarinecablemap.com/#/>



Damage to submarine cables is a daily problem for operators and is mostly caused by natural phenomena or accidents (earthquakes or landslides, damage caused by anchors or trawls). Remediation solutions based on technical intervention at sea and alternative transit of data traffic help to reduce the impacts.

Intentional, coordinated and targeted damage of all or part of the submarine cables of an intercontinental link could, however, have more serious consequences, particularly in terms of connectivity and service continuity⁴⁵.

Potential Courses of Action

Independently of or in addition to malicious acts carried out on the shore segment (shore stations or Internet interconnection points), an attack on the underwater part of submarine cables is a potential course of action, with possibilities ranging from a convenient “accident” in a coastal area, to deliberate military action⁴⁶. In this regard, the intrinsic features of the seabed make it the ideal theatre for non-attributable actions in “grey zones”.

Interception of data transiting via submarine cables is also a potential threat. Although action on the shore segment is easier than on the seabed due to the technical demands of taking action discreetly and efficiently, the practice of ‘looping in’ on the final splice of a submarine cable in deep waters remains a possibility.

1.4.1.2 Other Submarine Installations

Submarine communication cables are not the only strategic submarine installations liable to be threatened by action taken on or from the seabed. Other installations or activities may be under threat.

They include electric power transmission cables (located in shallow waters and buried), fossil fuel pipelines⁴⁷, underwater infrastructure in offshore wind farms⁴⁸, and exploration and extraction of mineral resources.

The update of the national strategy for deep-sea exploration and extraction of mineral resources, approved at the Interagency Committee for the Sea (CIMer) meeting in January 2021, establishes the priority of “conducting effective and rational action over time to explore the deep sea and acquire knowledge of underwater mineral resources [...] both in our EEZ and in the Area”⁴⁹. As consumption of raw materials consistently rises due to the double effect of industrialisation and demographic growth, free access to deep-sea mineral resources is becoming a strategic issue.

1.4.2 Our Armed Forces’ Freedom of Action could be Compromised

The development of both State and private activities on the seabed, together with a marked interplay of logic of might, fait accompli policies and a certain form of hybridity inherent in the physical features of the seabed could, eventually, restrict our freedom of action.

⁴⁵ In 2008, the severing of four submarine cables by a vessel at anchor off the coast of Egypt caused the loss of 90% of communications between Asia and Europe for a whole week, disrupting Internet in some fifteen countries. India lost 80% of its connectivity.

⁴⁶ Action that may be based on a combination of submarine insertion vehicles and deep-sea intervention means.

⁴⁷ France imports a significant proportion of fossil raw materials from northern Europe and Russia: almost 60% of the gas imported and 15% of the oil needed for our consumption travels through pipelines laid on the seabed. Today, the monitoring and risk control system put in place is determined by the potential environmental impacts of a technical incident occurring on these installations. In future, the weight of these installations in France’s energy supply could be a worrying vulnerability if they are not protected.

⁴⁸ Within the framework of the energy transition policy initiated in France, the number of offshore wind farm projects is growing. By 2026, 45 wind turbines should be in operation in the North Sea and off the coast of Dunkirk.

⁴⁹ «Stratégie nationale d’exploration et d’exploitation des ressources minérales dans les grands fonds marins : bilan et orientations, pour une nouvelle dynamique» – Jean-Louis Levet – January 2021.

1.4.2.1 In our Maritime Approaches

Naval interdiction, which is mainly implemented by means of naval mines, remains relevant, particularly in view of the advantages it offers in terms of hybridity, asymmetry and cost effectiveness. Similarly, the deployment by a strategic competitor of fixed or semi-fixed surveillance systems on the seabed could be an attractive course of action to restrict our armed forces' freedom of action in our maritime approaches.

In this respect, the proliferation of submarine systems, combined with developments made in decision-making autonomy, artificial intelligence, sensor performances and endurance of vehicles capable of operating from or on the seabed, is an important point for free access to our maritime approaches. The potential consequences of offensive and/or surveillance systems deployment on the safety of our approaches and the freedom of action of our armed forces are such that we must manage this threat.

1.4.2.2 In our Deployment Areas

As anti-access and area denial strategies are liable to be based on fixed or mobile underwater surveillance and denial systems, such systems could pose a growing threat to our armed forces and could jeopardise the credibility of the strategic "Intervention" function.

As an example, the Chinese maritime approach defence project⁵⁰ in response to surface and submarine threats, combines underwater surveillance systems⁵¹ and sophisticated weapons⁵².

It is therefore important to understand the reality of underwater surveillance and area denial strategies to contain the threat to an acceptable level for the freedom of action of our military and adjust our efforts as necessary.

1.4.3 Protection of Industrial and Military Interests could be Compromised

The development of deep-sea action capabilities by major powers but also private competitors is paving the way for the investigation or even the retrieval of sensitive information or objects submerged at great depths. After long being within the preserve of a handful of nations, this capability challenges the protection of our industrial and military interests as regards strategically sensitive objects or equipment lying at the bottom of the sea. With the enhanced performance and endurance of autonomous search sensors, combined with an accurate action capability, it is now possible to find and retrieve small objects from the seabed.

As strategic competition moves into maritime spaces, these are becoming the settings for increasingly frequent and intense power struggles.

1.5 Future of the Seabed, between Competition and Confrontation

With competition already underway, and confrontation likely, the seabed is turning into an area of conflict in the near future. Four issues are at stake: those relating to globalisation, particularly the economic aspects; those relating to energy and mining resources; questions about the environmental dimension and the protection of a fragile area; and finally, security and military stakes.

⁵⁰ «A2/AD, déni d'accès et interdiction de zone – réalité opérationnelle et limites du concept» - Etienne Daum and Bertrand Slaski – Les notes stratégiques – CEIS September 2018.

⁵¹ <http://www.matthewaid.com/post/83707009184/china-building-an-underwater-surveillance-system>.

⁵² <http://janes.com/article/65016/poly-technologies-integrates-coastal-defence-systems>.



Three major trends emerge from this observation: the first lays a wager on increased economic exploitation of resources, driven by private and/or public players. The second involves States playing a more direct role, by securing resources for example, or even by taking increasingly aggressive, predatory actions. The last trend underlines the lost gamble of global governance where, without respected multilateral agreements, a “might is right” situation could emerge.

Trend 1: The ramp-up of seabed exploitation/exploration by States and private companies

The acceleration of human activities, the first signs of which are already visible, could lead to heightened competition for resources. Driven, permitted and speeded up by technological innovations, seabed exploitation could spread into multiple fields, such as energy (drilling), mining and mineral resources, controlling communications by laying submarine cables (existing or future), automated underwater fleets, and even seabed tourism.

States could pursue four types of seabed exploitation and exploration strategies⁵³ :

- securing their supplies;
- guaranteeing the supply of rare metals for their industry;
- developing their economy;
- fuelling scientific knowledge.

Spurred on by a private sector in search of profit (GAFAM and BATXH as well as private actors in energy and mining), human activities on the seabed could increase, up to and including the possible emergence of submarine cities and tourist resorts. To reach these places, a proliferation of submarines and a democratisation phenomenon allowing large numbers of people to visit the seabed could develop, with inevitable difficulties in terms of safety of life and property, and the need to potentially guarantee water safety in very deep and difficult to reach areas.

Trend 2: Heightened Military Competition

Seabed warfare could gain speed by shifting from exploration to exploitation and from surveillance to security. The protection of installations and then entire areas would justify the assertion of strong national policies.

Initially defensive and based on access denial systems, this competition could turn into disputes with increased territorialisation of the seabed. The deployment of a growing number of military resources with increasingly aggressive capabilities could then create a real submarine arms race, with new, differentiating systems, such as permanent bases offering A2/AD capabilities.

Trend 3: The Impossible Status Quo of Multilateral Ocean Governance

Despite the rhetoric and attempts to make the seabed a global common where States Parties agree to declare their actions and limit their ascendancy, violations and circumventions could multiply further.

⁵³ These factors were partly noted in the Stratégie nationale d’exploration et d’exploitation des ressources minérales dans les grands fonds marins (Report by Jean-Louis Levet to the French Secretariat General for the Sea, July 2020).

Under pressure from public opinion, some States could flaunt a declaratory policy aiming to limit human and economic impacts on the seabed (reducing submarine energy farming and mining, ending the burial of polluting waste, destroying or recovering waste including munitions, etc.) but without actually allocating the resources to pursue it.

Behind the UN efforts to revitalise the ISBA so that it meets its primary mission⁵⁴, and despite declarations of intent, the effects could be limited, with States being tempted to use the law as an arm to pursue their claims. Competition could then arise over the norms to be applied, with a dramatic rise in international litigation, and an increase in *fait accompli* practices.

Between rampant competition and disputes, the seabed could then become a sort of «Undersea Far West» where a new form of «strategic piracy» comes into play.

To conclude, in a context marked by increasingly strong interplay between logic of might, *fait accompli* policies and the desire to capture resources, the seabed is becoming an area of strategic competition, and its control calls for the assertion of renewed ambition.

⁵⁴ As a reminder: «Promote the orderly, safe and rational management of the resources of the Area for the benefit of mankind as a whole, including through the effective protection of the marine environment and contributing to agreed international objectives and principles, including the Sustainable Development Goals.»



2 THE AMBITION TO CONTROL THE SEABED TO PROTECT OUR STRATEGIC INTERESTS

France has repeatedly asserted its commitment to the security of maritime areas, due to the freedom of action they allow, the resources they contain or the infrastructures they host. Today, the French ambition is underpinned by:

- The 2015 national strategy for the security of maritime areas, updated in 2019⁵⁵;
- The national strategy on the exploration and exploitation of deep seabed mineral resources, prepared in 2015, reviewed in 2020⁵⁶ and approved at the Interagency Committee for the Sea (CIMer) meeting on 22 January 2021;
- The France 2030 investment plan, presented in October 2021 by the French President, via Objective No. 10, "Invest in the seabed."

The French Ministry for the Armed Forces' seabed warfare strategy is fully integrated into this interagency dynamic and must help to preserve our capacity for anticipation and our freedom of action in underwater areas, thereby contributing to our national resilience. For these reasons, it must:

- **Guarantee freedom of action for our armed forces in the air-maritime environment;**
- **Contribute to the protection of our underwater installations (including submarine communication cables);**
- **Guarantee French interests in the exploration and exploitation of mineral and energy resources, in particular in areas under national jurisdiction;**
- **While being capable of posing a credible threat to the interests or forces of a potential enemy tempted to attack the interests of France or its strategic partners.**

At a time when the seabed is now emerging as a theatre of real strategic competition, controlling this area of potential conflict is an integral part of a strong national ambition aimed at guaranteeing our freedom of action and strengthening our strategic autonomy by taking advantage of technological, industrial and related cooperation opportunities.

2.1 Extend control of maritime areas to the seabed to guarantee the freedom of our forces

In response to diverse, evolving and possibly dual courses of action, integrating seabed warfare into the broader control of maritime areas requires a demonstration of our determination to:

- develop knowledge of the seabed, by measuring characteristic physical variables;
- monitor the seabed and ocean areas;
- take action on, from and towards the seabed.

⁵⁵ https://www.gouvernement.fr/sites/default/files/contenu/piece-jointe/2019/12/snsem_2019_finale.pdf

⁵⁶ «Stratégie nationale d'exploration et d'exploitation des ressources minérales dans les grands fonds marins : bilan et orientations : pour une nouvelle dynamique» – Jean-Louis Levet – July 2020.

Given the physical characteristics of the submarine area, which is an inherently opaque, difficult to access, vast and still little known environment, the solution to these three operational requirements must be thought out within a defined spatial framework, that is fully coherent with the potential threat and the performance and capabilities of our resources.

Seabed warfare will therefore focus primarily on the following area:

- the territorial sea, the French EEZ;
- any area of operational interest for the freedom of action of our armed forces and the protection of our national interests.

2.1.1 Develop knowledge of the seabed

Gaining detailed knowledge of the seabed and its immediate environment is an essential prerequisite for safe, autonomous and efficient action in the maritime domain.

In addition to supporting our nuclear deterrence posture at sea⁵⁷, this necessary understanding of the environment is part of the broader framework of preparing action for the purpose of assessing threats, establishing modes of action and optimising the performance of sensors.

For this reason, developing knowledge of the seabed also means developing our ability to measure, characterise and analyse the physical variables of the seabed and the surrounding ocean environment.

2.1.1.1 Improve our understanding of bathymetry and gravimetry

The dual need to ensure nautical safety of underwater vehicles and strategic autonomy in implementing assets, requires increased use of inertial navigation systems in order to strengthen the ability of our units to navigate with precision and use information and action systems, without systematically having to rely on external positioning (GPS, GALILEO).

This operational ambition requires improved precision and knowledge of deep-sea bathymetry⁵⁸ and gravimetry, because bathymetric and gravimetric readings allow precise positioning by inertial navigation updating on a known reference point.

Innovation in both acoustic and optical imagery must therefore help improve the representation capabilities of our military knowledge, data collection, surveillance and investigation tools.

R2-1 Support innovation in the development of sensors on board deep-sea AUV and ROV.

Similarly, knowledge of the seabed requires the ability to acutely detect any magnetic or electromagnetic anomaly in and on the seabed.

⁵⁷ Patrols conducted by the Ballistic Missile Submarines of the French Strategic Oceanic Force.

⁵⁸ Bathymetry is the science of measuring depths and landforms, making it possible to determine the topography of the seabed. Today, it uses acoustic (sonar) and optical (laser) imaging technologies.



Magnetic or electromagnetic detection methods based on the use of magnetic and electrical resistivity contrasts are promising and should be developed with a view to adequately designing on-board sensors. Improving magnetic mapping and manmade object detection methods is one of the current ambitions of the APOGé (geophysical operational applications) defence technology project of the French Hydrographic and Oceanographic Office (SHOM), which should be accelerated.

R2-2 Accelerate studies on physical variables for the detection of submarine installations.

2.1.1.2 Improve characterisation of the environment's response

Capability developments in the field of underwater detection, in particular to extend detection capabilities to ultra-low frequencies (ULF), requires increasingly expert knowledge of the environmental parameters likely to influence acoustic propagation conditions in these frequency ranges.

To understand ambient noise at ultra-low frequencies, which is essential for anticipating and optimising the performance of our sonar, regular and specific readings are needed to map it with the appropriate coverage and resolution.

Similarly, as the nature of the seabed determines the acoustic response of the ocean floor, detailed knowledge of the sediment is required in order to continue improving the accuracy of our acoustic propagation models.

R2-3 Study the particular modes of ultra-low frequency acoustic propagation.

While there is a definite need to expand multi-sensor hydro-oceanographic capabilities – even beyond the military field⁵⁹ – the preparation phase of the CHOF (Hydrographic and Oceanographic Capacities of the Future) programme for the modernisation of the SHOM's resources should seek to identify synergies with the more global seabed warfare initiative. The "develop knowledge" function may then require the implementation of mobile underwater systems capable of operating at depths of down to 6,000 metres, fully in line with the precision measurement requirements and bathymetric profiles found in the aforementioned areas of interest.

2.1.2 Monitor the seabed and submarine area

2.1.2.1 Monitor the Seabed and Sensitive Submarine Installations

Maintaining freedom of action for our armed forces and safeguarding French interests, which particularly includes contributing to the protection of our critical submarine installations, requires the ability, in peacetime, to autonomously detect and characterise any human underwater activity, in particular on the ocean floor.

⁵⁹ The 2021 update of the national strategy for the exploration and exploitation of mineral resources particularly includes seabed exploration to improve our knowledge of submarine ecosystems and mineral resources. Similarly, seabed exploration is a stated priority of the France 2030 plan.

For this reason, we should develop our ability to monitor, detect and search for – with the precision suited to the size of objects – any potential threat found on the seabed (mines, sabotage explosives, fixed or semi-fixed networks of surveillance devices, etc.) likely to impede the freedom of action of our armed forces or affect the integrity of submarine installations.

In order to be efficient, credible, and fully in line with our national ambition, this ability to monitor the seabed must be closely linked to our national interests (see paragraph 2.1).

Expand our capacity to monitor our areas of interest

Seabed surveillance operations will rely on the implementation of complementary assets (hull-mounted or towed sonar, unmanned underwater and surface vehicles, sonobuoys) that can be deployed from dedicated or ad-hoc naval and air-maritime platforms in order to be conducted over a vast bathymetric gradient extending from shallow waters to the deep ocean floor.

Considering the bathymetry found in the previously mentioned areas of interest, the ability to operate at depths of down to 6,000 metres is an ambition in line with our determination to preserve the freedom of action of our armed forces and efficiently contribute to monitoring and protecting submarine installations and our national interests. The detection and classification of a small object found in deep waters (attack device, listening device, remote sensor) requires an accuracy of measurement that can only be obtained with underwater vehicles (AUV, ROV) operating in the immediate vicinity of the seabed and equipped with complementary and efficient sensors.

R2-4 Increase our undersea search, surveillance and action capabilities to meet the needs inherent in maintaining freedom of action for our forces in areas with depths down to 6,000 metres.

In addition, it must be possible to deploy these seabed surveillance systems in maritime theatres or in areas of interest in order to support and secure a military operation. The air-portable nature of these surveillance systems, their compatibility with naval or possibly civil platforms and the existence of immediately available and long-term human resources are therefore essential.

Due to their design (supply-type hoisting device and wide rear platform, non-redundant position keeping), the various Metropolitan (BSAM), Overseas (BSAOM) and Chartered (BSAA) Support and Assistance Ships can today only be used in mild weather conditions, in a permissive environment and without any real possibility of concealing their payload.

The goal will therefore be to eventually have platforms for implementing autonomous or remotely operated vehicles, capable of carrying out search missions in conditions extended to discreet operations, in semi-permissive or non-permissive environments.

R2-5 Continue to analyse ways of deploying underwater surveillance vehicles in order to broaden the range of military options: air-portability, combat ships, submarines, etc.

2.1.2.2 Monitor the ocean area from the seabed

Monitoring an underwater volume with a detection network located on the seabed can have several roles: protection of approaches, supporting a force projection operation or discouraging a potential enemy.



This capability can be based on a combination of fixed, semi-fixed or mobile devices (antennas placed on the seabed, with or without a dedicated use, deployed surveillance devices, AUV, gliders, etc.), with a variable distribution and layout depending on the intended use, the environment encountered and the nature of the threat.

Guarantee the security of our maritime approaches

Our ability to deploy air-maritime forces far from their bases begins with the guarantee that they retain their freedom of action in our national approaches. This imperative above all concerns naval units directly involved in nuclear deterrence at sea: the ballistic missile submarines operating from the Ile Longue base and the *Charles de Gaulle* aircraft carrier from Toulon.

Studying the relevance of an underwater surveillance system located in our maritime approaches and implementing, in addition to undersea combat capabilities (nuclear attack submarines, surface ships with anti-submarine warfare capability, mine countermeasure capabilities, anti-submarine aircraft and helicopters), fixed, semi-fixed or mobile underwater detection methods, interacting from the seabed, would appear to be fully consistent with our aim of securing our maritime approaches.

In a context marked by a proliferation of underwater threats, these fixed or semi-fixed surveillance systems would have to form a network to allow for sensor complementarity and rationalisation – thereby optimising the processes of detecting, classifying and reporting threats – with a structure the nature and scalability of which will depend on the level of maturity reached by certain technologies currently being developed (artificial intelligence, mass information processing, autonomous navigation, energy storage, payload miniaturisation, underwater optical communications, etc.).

The decision to acquire such an ambitious military tool will therefore require a preliminary step of technical-operational and experimental studies in order to master the technologies and assess their acoustic detection performances.

Beyond anti-submarine security alone, this capability could be part of a broader framework of protecting our spaces and contributing to national resilience, through the ability to monitor ocean areas and detect possible threats to our submarine installations.

Monitor theatres of operations or areas of interest

In order to support the deployment of a naval force or to challenge a competitor over a maritime area, it is important to be able to assess the submarine activities that may be conducted there.

The projection and deployment of semi-fixed or mobile ocean surveillance systems, alone or in combination with anti-submarine and mine countermeasure units, can contribute to air-maritime manoeuvres by providing information on the presence, location or classification of manned or unmanned units operating in the volume of water observed. Whether deployed as a precaution or a response, these surveillance systems must be able to integrate with the naval force's sensors, for the purpose of managing information and collaborating in combat.

2.1.3 Take action on, from and towards the seabed

Following on from the "develop knowledge" and "monitor" missions, the consolidation of our capacity to take action on, towards and from the seabed, in an extended field of action that is coherent with our threat assessment, is a renewed ambition.

In the context of maintaining the freedom of action of our armed forces and protecting our national interests, it means being able to operate in deep waters, in response or in anticipation, openly or stealthily, with a broad spectrum of actions ranging from targeted investigations and neutralisation, to destruction,

recovery of sensitive objects, and restoration or salvage of an installation or underwater asset.

In line with our national ambition for submarine area surveillance, this capacity to take action on, from and towards the seabed will focus primarily on the territorial sea, the French EEZ and, occasionally, on any other zone of operational interest for the freedom of action of our armed forces and the protection of our national interests.

2.1.3.1 Develop our capacity to intervene under the sea

The ability to act down to a depth of 6,000 metres⁶⁰ meets the aforementioned requirement to control maritime areas and is in line with the development of our surveillance systems. In this regard, the accessibility of the ocean floor to a growing number of players, down to greater and greater depths, should prompt us to consider deeper use of our undersea intervention capabilities⁶¹.

Our deep sea intervention capabilities must take this reality into account, particularly with the aim of being able to act from time to time on the seabed, beyond what will be possible with the Maritime Mine Counter Measures of the Future (SLAMF), without jeopardising the efforts already made on this new programme.

R2-6 Make CEPHISMER a centre of expertise capable of implementing a military capability complementary to SLAMF for depths greater than 300 metres.

Like the surveillance and search assets, it must be possible to deploy action systems in maritime theatres or in areas of interest in order to support and secure a military operation. Their air-portable nature, compatibility with naval or possibly civil platforms outside metropolitan France, and the existence of immediately available and long-term human resources are therefore essential.

2.1.3.2 Develop our Capacities for Action in Disputed Environments

The growing number of disputed submarine areas will require greater use of particular subaquatic courses of action, with greater needs in terms of vehicle displacement and stealth.

Our ability to “horizontally” enter complex and disputed areas to conduct special subaquatic operations on, from and towards the seabed will therefore have to be maintained at the highest level, with requirements in terms of vehicle displacement, stealth and endurance.

2.1.4 Make further Use of Opportunities arising in the current Legal Framework

This means consolidating our strategy with a legal posture that integrates compliance with international law by maritime powers.

⁶⁰ With intervention resources limited to depths of 3,000 metres, only 24% of the seabed is accessible. By pushing this limit to 6,000 metres, 97% of the seabed becomes accessible.

⁶¹ France’s existing undersea intervention resources are unsuitable: the intervention capabilities of the Human Diving and Underwater Intervention unit, CEPHISMER, do not exceed 2,000 metres and are difficult to project and insufficiently equipped; SHOM has no intervention capability; only the National Institute for Ocean Science, IFREMER, has intervention assets that can operate down to 6,000 metres, but in limited numbers. These include a Remotely Operated Underwater Vehicle (ROV), Victor 6000, and a manned submarine, the Nautile, operational until 2025; the resources of French parapetrol or telecommunications operators (Orange Marine, Bourbon, etc.) are limited to 4,000 metres.



2.1.4.1 Support UNCLOS in response to attempted Instrumental Use

UNCLOS reconciles the rights of coastal States and third-party States by guaranteeing usage rules for maritime powers that are favourable to the strategic mobility of their armed forces. Supporting this legal order (freedom of the seas, right of innocent passage, rules for the delimitation of maritime spaces and non-appropriation of international spaces) therefore contributes directly to safeguarding the freedom of action of our armed forces on the seabed. As the majority of the Convention's stipulations have been recognised by the International Court of Justice as customary international law, i.e. applicable even to States that have not ratified it, UNCLOS represents a relevant and coherent framework for meeting the various challenges inherent in seabed warfare.

France sets great store by this balance and refuses any claim by a State making instrumental use of the Law of the Sea to further its control or exploitation of certain maritime areas. This is reflected by strategic guidance consisting in ensuring that effective freedom of navigation is maintained across all the oceans, thereby guaranteeing our freedom of manoeuvre and free access to resources, and by sharing our positions in all relevant forums, such as UN-DOALOS. In this respect, particular attention is paid to negotiations relating to a draft international agreement on the "conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction" in order to maintain the freedom of action of naval forces on the high seas.

Thus, in disputed maritime spaces (South China Sea, Eastern Mediterranean Sea, etc.), the French Navy units will continue their activities to assert the internationally recognised notion of freedom of navigation.

Reasserting the primacy of the principles and rules of existing international law of the sea also has a European dimension. Therefore, France leads the cross-cutting theme of Europe's free access to strategic common areas (cyber, space, maritime) in the work on the "Strategic Compass", due to be adopted in March 2022.

2.1.4.2 Adapt the National Legal Framework to our Ambitions

In domestic law, the development of less permissive national regulations to avoid circumvention of the law and improve knowledge of maritime activities is under way. Some States may indeed be tempted to make use of the progressive obsolescence of certain legal norms induced by technological developments⁶².

With this aim, French Decree 2013-611 is currently being revised under the coordination of the Secretariat-General for the Sea (SG Mer), to require operators to give prior notice of the routes of all cables laid in the French EEZ and on our continental shelf. We are also seeking to define a legal framework for studies carried out prior to the laying of cables, with the introduction of a system of authorisation in territorial waters and of notice in the EEZ and on the continental shelf.

R2-7 Complete the project to revise national regulations on the laying of submarine cables (system of authorisation in the territorial sea and of notice in the EEZ).

In addition, Ordinance No. 2021-1330 of 13 October 2021 on navigation conditions for autonomous ships and maritime drones now provides a legal framework for State representatives at sea to take appropriate enforcement measures. AUV navigation in our territorial waters will now be subject to their prior authorisation.

⁶² This is particularly the case for the 1884 convention on submarine cables, which does not take into account the acoustic, seismic or magnetic data collection capabilities of next-generation cables, which can detect natural events (earthquakes, tsunamis).

R2-8 Integrate the supervision of “autonomous vessel/maritime drone” activities into the regulations for State representatives at sea.

With regard to the monitoring of activities conducted in our areas of maritime jurisdiction, Decree No. 2017-956 of 10 May 2017 provides for the possibility of creating “areas within the protection of national defence interests” defined by an order of the French Prime Minister in which MSR activities are subject to authorisation by the French Ministry for the Armed Forces and to specific rules on the publication of data collected. The French Ministry for the Armed Forces will propose an order in 2022 to provide a protective framework for the sectors identified by the French Navy and France’s defence procurement agency, the Direction Générale de l’Armement (DGA).

R2-9 In an order issued by the French Prime Minister, define the areas within the protection of national defence interests for the purpose of marine scientific research.

Finally, and again in the context of MSR, Article 249 of UNCLOS allows a coastal State to ask for an observer to be permitted on board foreign scientific vessels operating in its EEZ. France reserves the right to make use of this possibility, if necessary.

2.2 Seize Opportunities to Consolidate our Strategic Autonomy

2.2.1 Take Advantage of Breakthroughs in Technology and Usage

Innovation and research in technologies for accessing the seabed and operating systems that may be positioned there is highly dynamic. In this respect, in order to control the seabed and respond to defence-related challenges, advantage should be taken of expected technological and usage breakthroughs in vehicle endurance, autonomous decision-making, sensor miniaturisation, data processing, submarine communications and robotics.

In the field of autonomous underwater vehicles

Energy: advances made in battery technology for electric vehicles will increase the endurance of AUV. Similarly, research in the field of induction charging could make it possible to consider developing docking stations located on the seabed where drones could charge regularly. These underwater energy storage and distribution stations could also act as a communication relay between an AUV and its control system. Progress in energy-efficient components will also boost the endurance of systems.

Navigation: component miniaturisation and improved processing capacities now allow high-performance inertial units to be integrated onto autonomous underwater vehicles.

Developments in gravimetry (on-chip cold-atom gravimeters, digital terrain correlation) and stellar resetting will improve the endurance and navigation accuracy of submarine systems, both of which are key factors in conducting long-term missions in complex environments.

Detection: thanks to increased processing capacities and artificial intelligence (AI), AUV now have adapted, high-performance and complementary detection sensors, both for searching vast expanses



and for classifying or even identifying objects on the seabed (“wide field” detection using multibeam sonar with constant progress in terms of resolution and “swath” width; classification/identification by synthetic array sonar, high-resolution optical camera, laser photogrammetry or imaging in future; use of AI to improve processing capacities, etc.). Similarly, technological developments in magnetic detection (optically pumped magnetic detectors, colour centre detectors) promise a steady improvement in performance in this area, particularly for the detection and monitoring of sensitive objects such as submarine cables.

Communications: improvements in underwater communications, in terms of data rate, range and security, are directly linked to the ability of AUV to conduct complex missions, alone or as part of a network. Various research projects are being conducted on underwater communications, based for the most part on acoustic technologies (coding and error correction techniques, communication networks using relays [drones, buoys, fixed facilities], laser communications etc.)⁶³.

In the field of ROV

In addition to the technologies mentioned above, technical advancements in robotics pave the way to improved performances for remotely operated underwater vehicles, in terms of endurance, precision and mission diversity:

- simplified controls (joystick) for operators allow more precise technical moves;
- interfaces providing operators with better information (tactile information, force feedback, depth perception, etc.);
- robot arms with a high number of degrees of freedom and adapted control interfaces;
- architectures (engines, controls) allowing very precise movement and positioning;
- high-performance battery stores removing the need for power cables to facilitate certain missions.

Likewise, expected improvements in the stabilisation of implementing vessels (hull shapes, stabilising fins, control systems, observation sensors for platform movement prediction, with real-time processing software, etc.) should allow these autonomous or remotely operated systems to be used in a wider range of climatic conditions.

2.2.2 Make Seabed warfare an Area of Excellence for France

2.2.2.1 Develop DTIB Expertise

French industrial manufacturers currently have certain skills and knowledge that are vital to seabed warfare, particularly in underwater works, carriers, sensors and communication systems. However, experience of deep waters (more than 3,000 metres) is scarce. Work produced and products made in recent years for depths between 3,000 and 6,000 metres have mainly been instigated by scientific and oceanographic research.

Consequently, few “deep water” ROV/AUV for monitoring or taking action 6,000 metres below the surface have been developed and produced by French industry so far.

⁶³ Underwater communications have gained by research conducted for space, once again illustrating the similarity of issues between these two environments. In 2017, NASA and the Lincoln Laboratory proved the ability of a laser to transmit data at high speed over a very long distance. More than 385,000 km away, the satellite emitted traffic at a speed of 622 megabits per second, during the second Lunar Laser Communication Demonstration (LLCD). This data transfer technology, which has been successfully transposed to the undersea environment, brings hope of significant operational gains and especially improved coordination of air-maritime systems in the context of anti-submarine warfare.

Only IFREMER has and uses a coherent set of capabilities suitable for exploring and observing down to 3,000 metres and taking action down to 6,000 metres.

France also has research and testing capabilities that could support the ramp-up of a national sector (Ecole Centrale Nantes, ENSTA Bretagne, IFREMER, DGA Technique Hydrodynamique and Technique Navale in particular).

The DTIB should be able to provide certain strategic capabilities in order to:

Develop knowledge of the water column: it will be important to expand the scope of measurements and their field of use to fully meet needs for water column knowledge down to great depths.

Develop knowledge of and monitor the seabed: in this respect, command of numerous technological building bricks is vital to have a reliable and high-performance capability (high pressure seabed imaging, geolocating and relocalisation, underwater communication, autonomous submarine navigation, decision-making autonomy for adaptation to any environmental interference, energy self-sufficiency).

It will also be vital to master the overall architecture into which these technologies are integrated.

Conduct operations on the seabed: the ability to act near to or directly on the seabed at great depths is currently provided by two families of objects: manned submarines and remotely operated underwater vehicles (ROV). The complexity of the operations to be conducted currently requires direct human intervention; men are either present or remotely linked to the ROV by an electromechanical cable.

Several French companies have expertise in medium-capacity or deep-sea ROV but none offer off-the-shelf vehicles. Since 1999, IFREMER has also been operating the ROV Victor 6000 developed with support from several industrial partners. The design experience of this ROV which is now twenty years old shows that the development and production of such a system requires command of a whole array of technological building blocks such as lighting and electro-optical imaging in high pressure environments, positioning, propulsion, robotics for the articulated arms, and electric optic carrier cables.

Lastly, IFREMER has expertise and knowledge in the design and operation of these two vehicles: small manned submarine⁶⁴ and remotely operated underwater vehicle.

At this stage, therefore, French industry only covers some of the technological building blocks necessary to develop a next-generation ROV.

Special attention should therefore be paid to ensure that the DTIB can meet the vital security needs of the State, taking into account the additional issues of sovereignty on certain sensitive capabilities.

Synergies with seabed investment projects supported by the France 2030 investment plan (objective no. 10) will be looked for, particularly in relation to the France 2030 projects to acquire deep-water ROV/AUV that will serve to build the deep-water ROV/AUV capabilities of this strategy, subject to their confirmation.

R2-10 Support DTIB development in command of sensitive capabilities, by taking advantage of solutions developed for civil needs and in line with the France 2030 plan.

⁶⁴ Since 1984, IFREMER has operated the Nautilus which is currently deployed from the vessels «Atalante» and «Pourquoi-Pas». Equipped with two titanium half-spheres, guaranteeing complete sealing by simple metal-on-metal compression, Nautilus is one of the few systems in the world to allow three passengers to operate 6,000 metres below the surface. Its simple and robust design renders it highly adaptable to new payloads. As the irreplaceable components such as the two titanium half spheres are not subjected to fatigue, Nautilus has no precise lifespan in theory.



2.2.2.2 Develop Partnerships with Civil Operators

Seabed warfare and its related applications, in terms of deep diving, autonomous underwater navigation, marine scientific research, energy storage, payload miniaturisation, resistance to strong pressure and use of fibre optics for monitoring sensitive installations – all of which are areas presenting synergies between industrial activities and those of the Armed Forces Ministry due to their potential dual use – argue in favour of developing specific partnerships with certain civil operators, with compensation that needs to be defined.

2.2.3 Developing our International Partnerships

2.2.3.1 Existing Cooperation

Cooperation already initiated with some of our foreign partners in the field of seabed warfare mainly involves bilateral or multilateral exchanges, or dialogue on strategy and/or maritime security between States.

In Europe, our principal partners are Belgium, Spain, Greece, Italy and the United Kingdom in the field of mine warfare and/or underwater rescue; Norway, the Netherlands, Portugal and the United Kingdom for Hydrography - Oceanography - Meteorology (HOM). Outside Europe, exchanges also take place with the United States, India, Israel, Lebanon, the Gulf States and the Maghreb countries in the field of mine warfare, and with the United States, Australia, India, Indonesia and the Maghreb countries on HOM.

2.2.3.2 Possible Cooperation

Possible international cooperation in seabed warfare must be able to meet diverse challenges, relating to the exercise of our sovereignty over areas under national jurisdiction, and to the safeguarding of our strategic and economic interests. It will be necessary to:

Guarantee the exercise of our sovereignty and freedom of action: as France has the second-largest area of maritime jurisdiction in the world, thanks to its overseas territories in particular, we must be able to exercise our sovereignty over vast expanses, from metropolitan approach zones to exclusive economic zones in the Indian Ocean and the Pacific. As our resources are limited, developing partnerships – primarily in areas that we will not be able to cover entirely – must allow us to rise to two key challenges:

- guarantee freedom of action for our naval forces, primarily those of the oceanic deterrent component based on ballistic missile submarines, which requires maintaining a high level of knowledge of potential deployment areas;
- contribute to protecting our submarine installations and resources located in our areas under national jurisdiction. In this respect, our overseas territories are an asset, as their geographical footprint justifies our approaching partners to share intelligence on submarine activities.

Safeguard our strategic and economic interests: beyond these questions of sovereignty, France will need to find a balanced position in its partnerships which preserves its strategic and economic advantages (supporting national operators and developing the DTIB).

Although interest in seabed warfare is increasingly shared, the level of knowledge and investment at political, economic, technical and military levels differs greatly from one country to another. Beyond the current situations, ambitions also diverge. The benefits of these possible partnerships must therefore be assessed in light of the efforts made by our partners and their stated ambition.

3 ROADMAP

3.1 Integrate seabed warfare into our defence strategy

3.1.1 Military operations for seabed warfare

The ability to guarantee France's capacity to meet the seabed warfare ambitions means that the armed forces must define a classification of seabed warfare operations and a framework for their use. These operations encompass all the activities conducted by the French Ministry for the Armed Forces, or for its benefit, from, to and on the seabed

3.1.1.1 Definition

Contributing to the freedom of information, access and action of our armed forces and the protection of our strategic interests, seabed warfare operations include implementing, deploying and utilising fixed, semi-fixed or mobile underwater capabilities able to operate towards, from and on the seabed, either independently or in a network.

These operations contribute to the freedom of action of our armed forces, the protection of our submarine installations (including submarine communication cables) and our national interests relating to the exploration and exploitation of mineral and energy resources, while still being capable of posing a credible threat to any interests or forces of a potential enemy tempted to attack our national interests.

3.1.1.2 Framework for use

Given the diverse, evolving and possibly dual modes of action in the field of underwater action, seabed warfare operations are part of a more global framework of controlling maritime areas and are an integral part of a strong national ambition to safeguard our capacity for anticipation, action and contribution to our national resilience.

Seabed warfare operations are organised around three main functions:

- developing knowledge of the seabed;
- monitoring the seabed and ocean space;
- taking action on, from and towards the seabed.

3.1.1.3 Developing knowledge of the seabed

This function must allow seabed and the ocean environment's physical quantities to be measured, characterised and analysed for knowledge and anticipation purposes. It is based on:

- hydro-oceanographic missions consisting of reading, analysing and storing collected data: bathymetric surveys and gravimetric measurements, which are essential for the nautical security of underwater vehicles and the capacity of our armed forces to act autonomously; magnetometry measurements for characterising magnetic anomalies, the nature of the seabed for controlling acoustic sensors, particularly in ultra-low and very-low frequencies; diverse factors such as velocity profiles, ambient noise readings, transparency of the environment; mapping of submarine cables in our approaches (P1) and in certain points of passage (P2), etc. Depending on their degree of confidentiality or the permissiveness of the data collection environment, these operations can be carried out by sovereign military means, via exchanges with certain allies, or through a trusted partner⁶⁵;

- mine warfare sounding survey missions to maintain full knowledge of the seabed in connection with our strategic lines of communication and exit routes of certain strategic vessels. These operational data collection missions ensure the efficiency of mine warfare means deployed both in peacetime and times of crisis, in support of deterrence, protection of points of vital importance and the intervention of a projected air-maritime force;
- special REA⁶⁶ actions in a disputed area, which aim to discreetly penetrate, underwater, in the depth of an enemy's system, to collect the GHOM⁶⁷ information necessary to prepare special naval action or an amphibious operation in a port or area of strategic interest. The aim is to gain a detailed understanding, in a non-permissive environment, of environmental data on the underwater volume and the coastal zone (detailed bathymetry of coastal approaches, turbidity or bioluminescence of the underwater volume, footprint and nature of the seabed, etc.).

Whether they are carried out in a permissive or non-permissive environment, these operations to gain knowledge of the seabed and its related environment rely on the use of multi-sensor capabilities, based on the complementarity of sensors and effectors in order to optimise the search and limit the constraints.

3.1.1.4 Monitor the Seabed and the Ocean Space

The seabed warfare operations associated with this function include:

- monitoring the seabed and critical submarine installations, in our maritime approaches (territorial sea and EEZ) and in any area of interest or theatre of operations;
- monitoring the submarine volume from the seabed, by deploying and using underwater detection networks to protect our approaches and support armed forces and power projection operations.

3.1.1.5 Taking Action on, from and towards the Seabed

The typology of operations associated with the «take action» function includes:

- searches and investigations undertaken to dispel a potential doubt, characterise a threat and, if necessary, prepare the underwater intervention. To support surveillance operations, it must be possible to conduct a targeted investigation based on an initial detection or sign of a threat, prior to any neutralisation, destruction, retrieval or salvage operation;
- intervention, in order to neutralise, destroy or retrieve devices that could threaten the freedom of action of our armed forces or critical installations;
- the repair or salvage of an underwater object that has suffered a physical attack on its integrity and/or security;
- search and retrieval of sensitive objects or objects containing sensitive information (missile debris, flight recorder black box, etc.).

⁶⁵ Under the MN Ifremer Shom agreement, the naval and remotely-operated resources of the French Oceanic Fleet (FOF) can be used for 130 days per year.

⁶⁶ Rapid Environmental Assessment.

⁶⁷ Geography, Hydrography, Oceanography, and Meteorology.

3.1.2 Specify the doctrine

3.1.2.1 The specificity of the seabed

As the issue of the seabed gains ground, the question arises of its position in the multi-domain environment.

While the seabed is not a compartment or a field in its own right, it nonetheless represents a new area of conflict, requiring close monitoring and specific doctrine.

3.1.2.2 Drafting the doctrine

Integrating the seabed issue into the overall maritime strategy cannot be limited to merely identifying and explaining the operations mentioned above. It will require the development of a specific corpus of doctrine, detailing the framework, organisation, principles and tools needed to conduct military action.

To remain pertinent, this doctrine must support technological developments on topics as fundamental as submarine communications, use of underwater vehicles and mass data processing. It will be drafted to take into account the concerns of our European partners and within the Atlantic Alliance, without compromising on any specific national ambition or need.

Lastly, once the scope of the missions, resources and operations is clearly defined, it should be integrated in the form of operational agreements, and then updated each year during the annual updates of the PIA 0.1 – operational agreements for availability of operational capabilities – in the chapters on the naval force and operational controllers having capabilities.

R3-1 Pursue the process of integrating seabed warfare into the doctrine.

3.1.3 Anticipate and analyse threats

For seabed warfare, current and future threats to our national interests and the freedom of action of our armed forces must be characterised.

In specific terms, the French Ministry for the Armed Forces' affiliated intelligence directorates will contribute to the three steps of detecting and identifying potentially hostile actions, understanding and characterising our competitors' and potential enemies' intentions and designating responsibility for these actions.

3.2 Define governance of the response

3.2.1 Introduce seabed governance within the Ministry for the Armed Forces to guarantee visibility and coherence

A permanent organisation dedicated to the seabed warfare topic will be placed under the supervision of a coordination authority within the French Naval Staff. This organisation will meet the dual aim of achieving visibility and coherence in the doctrine, organisation, equipment and human resources devoted to this field.



It will particularly aim to:

- coordinate the various areas of expertise contributing to seabed warfare (hydrography-oceanography, mine warfare, undersea intervention, human diving, submarine survival/salvage, acoustic intelligence) and entrusted to entities belonging to different authorities;
- contribute to the expression and regular review of the operational requirement in connection with the capability development process adopted;
- identify common issues in order to optimise strategies, such as skills generation, equipment acquisition and infrastructure construction.

This coordination authority will rely on the expertise of the organic authorities and all the offices of the French Naval Staff and military personnel directorate.

3.2.2 Monitor through Efficient and Inclusive Coordination

The coordination process implemented will have three purposes:

- imprint a dynamic aiming for coherence and operational performance, and foster, to this end, mutual awareness of players contributing to seabed warfare;
- meet the operational need and improve the efficiency of the armed forces in the execution of their missions by closely coordinating the different players and federating the work of the different defence staffs;
- define directions each year on the topic of seabed warfare by making the necessary corrections and adjustments to ensure consistency among the different capabilities, based on feedback and a forward-looking vision;

Ultimately, the coordination of seabed warfare should also help to identify the strengths and weaknesses of the operational capabilities. Through this process, priorities will be proposed to the Chief of Defence Staff where necessary.

The coordination will be overseen by the working group created to draft this ministerial strategy. Organised around the key stakeholders on the topic, i.e. EMA, EMM, DGRIS, DGA, DAJ, AID, DPID, SHOM and the intelligence services, this committee, steered by the Defence Staff, will lead several working groups focusing on the six DOTMPF⁶⁸ pillars. To guarantee coherence and the broadest coordination possible, entities and organisations of other ministries will be involved on topical matters, such as the SGMER for seabed exploration and exploitation issues.

At the year end, or as required, the working group will present its work to the ministry.

R3-2 Keep the ministerial working group created to draft this strategy and, as required, include other organisations and ministries contributing to seabed warfare. It will oversee the topic from the DOTMPF perspective, with the aim of achieving visibility, efficiency and overall coherence. It will report yearly to the ministry.

⁶⁸ Doctrine, Organisation, Human Resources, Equipment, Support, Training

3.3 Prepare the Capabilities needed to achieve our Ambition

3.3.1 Coherence with existing Programmes

Several existing or future arms programmes are already stakeholders in seabed warfare :

- the CHOF programme (Hydrographic and Oceanographic Capacity of the Future) contributes to the “knowledge” component of seabed warfare;
- the SLAMF programme (Maritime Mine Counter Measures of the Future) contributes to all the components of seabed warfare, i.e. “knowledge”, “monitor” and “take action”, but only for its specific missions.

The advisability of equipping systems developed as part of the CHOF and SLAMF programmes with the ability to launch and retrieve USV and AUV and therefore capable of taking on all or part of the new seabed warfare capabilities, will be studied. Potential synergies between these programmes and a possible additional «seabed warfare» programme will continue to be sought.

Similarly, from a technological standpoint, some sensor, effector or platform building blocks could be shared between these programmes. Efforts to be coherent will be pursued.

3.3.1.1 CHOF

The CHOF programme aims to renew the hydrographic and oceanographic capacity of the French Navy with a core set of capabilities using disruptive technologies (USV and AUV, and artificial intelligence in particular), ensuring continuity of the requirement and a responsive and discreet surveying capacity, followed by increments to gradually reach the optimal capacity to meet the growing need for surveys.

The preparation phase under way aims to define the architecture of the next-generation hydrographic vessels and assess the various possible choices for payloads (drones) in order to meet growing needs in hydrography (twofold increase in surveying capabilities, 10% increase in the surface area to be covered, improvement in responsive and discreet surveys).

In this context, USV (DRIX), medium depth AUV (AUV “Gavia” from Teledyne, AUV A18D from ECA) and a deep-sea AUV (Hugin 6000 – Kongsberg) were trialled in 2020 and 2021.

This component will bring the capacity to deploy USV, UAV and AUV.

3.3.1.2 SLAMF

The SLAMF (Maritime Mine Counter Measures of the Future) programme aims to incrementally renew France’s maritime mine counter measures capability. The programme should expand and modernise this capability by introducing robotised solutions, filling gaps, distancing humans from the threat and improving detectability in external operations.

Step 1 of SLAMF initiated in October 2020 aims to support deterrence in addition to the existing CMT (tripartite class mine hunters), primarily with the acquisition of the first four mine counter measure modules. A mine counter measure module can use the following elements: a USV with towed sonar; a USV equipped with a remotely-operated robot to relocate, identify and neutralise the mine; two AUV with sonar that can do the detection, classification, locating sequence autonomously.

The next steps which are scheduled for launch early in 2023 will add the high seas component: the mine warfare vessel, the full capability with the acquisition of the mine counter measure module and additional AUV, as well as the bomb-disposal diver support ship.



This component adds capacity to deploy USV, UAV and AUV.

3.3.2 Developing New Capabilities

3.3.2.1 Launch of Capability-Building

In conjunction with the Naval and Army Staff, a dual process has been launched by the DGA to meet seabed warfare requirements for the aspects not addressed by the aforementioned programmes and operations:

- accelerated capability experimentation and exploration;
- long-term capability development.

Accelerated Process: A First Exploratory Capability

An accelerated capability experimentation and exploration process was launched in April 2021. It aims to assess a first deep seabed surveillance and intervention capability (down to 6,000 metres) consisting of equipment already tried and tested by the Oil & Gas industry or scientific research and available off-the-shelf, preferably nationally. On the one hand, it will provide a first exploratory capability dedicated to seabed warfare and, on the other, it will pursue capability development work while honing the concept of use of certain capabilities.

This first capability will consist of:

- a deep-sea AUV for the “knowledge” and “monitor” functions;
- a deep-sea ROV for the “action” function.

The overall timescale of the accelerated process is:

- October 2021: experimenting the deep-sea AUV in the context of CHOF;
- 2022-2024: AUV and ROV experimentations and implementation.

Capability-Building Process

A capability development process was launched in the first half of 2021 to define the overall seabed warfare capability requirement. An in-depth functional analysis is currently under way to identify the scope of the seabed warfare capability not yet covered by existing programmes, i.e. the ability to develop knowledge, monitor and take action in depths down to 6,000 metres. This functional analysis will be followed by studies considered necessary in terms of operational and technical-operational analysis, defence technology studies to reach targeted TRLs, and feasibility analyses to define and correctly scale a programme. This whole capability-building analysis could give rise to an orientation brief, to guarantee the overall coherence of the constituent elements of this capability, including over the long-term.

Subject to confirmation by the capability development work, and **for illustration only**, a ramp-up could take place as follows:

- A first capability increment by 2025 requiring short-term funding, consisting of:
 - o one AUV 6000 and one ROV 6000 to form a first «deep water 6000» capability;
 - o one AUV 3000 and one ROV 3000 to form a first «medium depth 3000» capability;

- o DTIB maturity actions could also be taken to prepare the next capability increment;
 - o use of vessels of opportunity.
- acquisition of a supplement forming capability increment no. 2 by 2028 requiring short-term financing, providing a permanent warning capability on the two shorelines (Atlantic and Mediterranean) and a specific capability for projection in an external operation representing a total capability of:
- o two AUV 6000 and two ROV 6000;
 - o two AUV 3000 and two ROV 3000;

The capability development work may justify a third increment in order to better scale the capabilities to needs:

- o additional AUV 6000 to meet urgent relocation needs;
- o dedicated platform.

3.4 Consolidate expertise in seabed warfare

The inclusion of seabed warfare in our defence strategy should rely on a “human resources” (HR) component to guarantee achievement of the stated ambition. This will involve:

- identifying needs to reinforce existing capacities and implement new ones;
- defining the related training needs;
- successfully opening up to the worlds of higher education, research and industry, with a view to cross-fertilising expertise.

3.4.1 Meeting the Need

The stated ambitions for undersea intervention and use of fixed or semi-fixed submarine surveillance systems will come with new HR needs, both in terms of skills and numbers.

The Human Diving and Underwater Intervention unit (CEPHISMER) will need reorganising and reinforcing to guarantee its ability to meet operational requirements in the fields of undersea search and action.

The HR component should be adapted in quality and number for the acquisition and processing of mass data on the new systems implemented.

Furthermore, the use of fixed or semi-fixed ocean surveillance systems will represent a new need, covering watch, analysis, correlation and real-time interpretation of data from different submarine sensors. Submarine detection trials conducted using fixed systems will provide input to fine-tune the HR requirement.



R3-3 Define the human resources needed for the proposed ambitions in the short and medium term, for undersea search and action.

3.4.2 Generate Skills

Training will need to evolve to generate human resources capable of conducting these new missions.

In this respect, training of certain specialities in the Armed Forces should be broadened to include the use of new equipment such as remotely operated or autonomous underwater vehicles. Some specific training courses could be outsourced, and this opening would create opportunities for exchange and cross-fertilisation with the worlds of research and industry developing or implementing similar capabilities.

It will then be necessary to decide on the operational need for specific knowledge, such as saturation diving. If necessary, the French Naval Force should acquire the training tools needed to maintain or develop these skills.

Lastly, new curricula will be developed to meet new needs. Use of fixed acoustic surveillance systems will require new training courses, combining knowledge of acoustic detection and ultra-low frequencies, mass data use and processing, and even operational interpretation of the physical properties of optical fibre.

R3-4 Accurately assess existing skills and identify possible recruitment and training sources to define career paths adapted to the implementation of new capabilities required by seabed warfare : implementation and maintenance of autonomous and remotely operated underwater vehicles, saturation diving, detailed knowledge of the undersea environment, underwater detection in the ultra-low frequency range, mass data processing and management.

3.4.3 Foster Emulation through Partnerships

The quest for excellence in seabed warfare should prompt the Ministry for the Armed Forces to develop partnerships with higher education, research and industry, with a view to cross-fertilising expertise and knowledge, in a dual-use field propitious to disruptive innovation.

France has definite assets, with proven skills and an ecosystem boasting a great diversity of players (state and institutional players, research centres, industrial groups, SME/mid-caps, etc.) These stakeholders are mainly based in Brittany, in the PACA region in the south of France and, to a lesser extent, in and around Paris. Given this situation, it will be necessary to federate skills and players to help develop expertise and a sector at the national level.

Like the example of cyber⁶⁹, the creation of a pole of excellence with the mission of stimulating development of the training offer, academic research and the technology and industrial base could contribute to this necessary federation of players. Motivated partners will be needed to initiate this centre and give it a truly national role. The Brittany region already has experience in creating the cyber pole of excellence that has a large number of academic players (schools, universities, research institutes). It could therefore be an appropriate location for the creation of this pole of excellence.

R3-5 Identify and select partners in research, education and industry that are willing to create a national «deep seabed» pole of excellence, and prepare for its creation.

⁶⁹ The cyber pole of excellence was initiated in 2014 in the form of a non-profit organisation by the Ministry for the Armed Forces and the Brittany region. Today, it has around forty active members and carries out both national and international work. A permanent team of some ten people leads the centre and the thematic working groups, searches for funding and organises projects. The pole has a board of directors comprising representatives of the main entities involved (MINARM, ANSSI, Brittany Region).



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Private Staff

Captain Lambropoulos, Sea Deputy

SGDSN

Captain de Jaurias, Secretariat-General CDSN (Defence and National Security Council)

SGMer

Commissioner General de la Burgade, Deputy SGMer

Mr Jean-Louis Levet, Special Advisor for the national deep seabed strategy

Chief Commissioner Jean-Baptiste Gongora, Representative

MINARM

Colonel Quentin Bourgeois, Deputy Director of the Doctrine Division (CICDE)

MEAE

Mr Jérôme Douaud, Director of Strategic Affairs

Mr Pierre Bianconni, Deputy Director of Law of the Sea

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Mr François Houllier, CEO of IFREMER

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Mr Jérémie Maillet, VP Marine Operations, ASN Marine Managing Director

Mr Michel Colinet, Associate Director, ABYSSA

Mr Philippe Novelli, CEO, ECA

Mr Joseph Leroy, CTO, SUBSEA SEVEN

Maritime Ecosystem

Mr Francis Valat, Honorary President of the Cluster Maritime Français

Mr Frédéric Moncany de Saint-Aignan, President of the Cluster Maritime Français

Experts:

Mr Nicolas Mazzucchi, FRS



APPENDIX 2 – GLOSSARY

AUV	Autonomous Underwater Vehicle
CEPHISMER	Human Diving and Underwater Intervention unit of the French Navy
CHOF	<i>Capacité Hydrographique et Océanographique Future</i> Hydrographic and Oceanographic Capabilities of the Future
CMT	Tripartite class mine hunter
CVBG	Carrier Vessel Battle Group
EEZ	Exclusive Economic Zone
FOST	Strategic Oceanic Force
IFREMER	<i>Institut français de recherche pour l'exploitation de la mer</i>
ROV	Remotely Operated Underwater Vehicle
SLAMF	<i>Système de Lutte Anti-mines du Futur</i> Maritime Mine Counter Measures of the Future
UNCLOS	United Nations Convention on the Law of the Sea
USV	Unmanned Surface Vehicle