Istituto Affari Internazionali

The Underwater Environment and Europe's Defence and Security

edited by Elio Calcagno and Alessandro Marrone

ABSTRACT

Technological advancements in the field of uncrewed underwater vehicles (UUV) and the increasing number of underwater critical infrastructures (UCI) – such as pipelines and internet cables – have made the environment below the seas' surface a prominent stage for geopolitical competition. The Nord Stream sabotage clearly demonstrated that UCIs are vulnerable to covert actions that are difficult to prevent or attribute. Moreover, operating in this challenging environment requires mastering advanced technological solutions to cope with high pressures and the opacity of water, which severely limits or denies wireless communications technologies commonly used above the surface. Large and mid-sized navies around the world are enhancing their submarine fleets or acquiring this technology for the first time, leading to an ever more competitive and contested underwater domain. Italy has launched the Near Future Submarine programme by relying more than in the recent past on domestic shipbuilding and defence companies, and is establishing a National Underwater Hub aimed at fostering technological cooperation between military and civilian, as well as public and private actors.

Italy | France | Germany | UK | Russia | China | Indo-Pacific | Maritime security | NATO | EU | Defence industry | Military policy | Procurement

keywords

DOCUMENTI IAI 23 | 13 - JUNE 2023

ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

The Underwater Environment and Europe's Defence and Security

edited by Elio Calcagno and Alessandro Marrone*

Table of contents

* Elio Calcagno is Researcher in the Defence Programme at the Istituto Affari Internazionali (IAI). Alessandro Marrone is Head of the Defence Programme at IAI.
This study also reflects the findings of the seminar "Italy, the Wider Mediterranean and the Underwater Domain", held in Rome on 30 May 2023.

Executive summary

The global economy has never been more reliant on the sea than today, making the maritime space a hotly contested space, where well-established and rising powers alike are working on increasing their own military capabilities. Operating underwater requires mastering technological solutions to the extremely high pressures that characterise deep water environments. Crucially, the physical properties of water make methods of wireless communication commonly used on the surface, in the air and in space an unviable or sub-optimal solution for underwater communications.

Technological advancements, especially in the field of uncrewed underwater vehicles (UUV) thanks also to recent breakthroughs in the field of around autonomous underwater vehicles (AUV), have contributed to making this environment more accessible. Consequently, underwater critical infrastructures (UCI) such as telecommunications cables and oil and gas pipelines are more vulnerable to disruption, sabotage, or broadly speaking military action. In this context, navies cannot avoid grappling with the concept of seabed warfare and developing new doctrines and requirements accordingly.

At the same time, submarine warfare is experiencing a renaissance of sorts, with more countries then ever looking to equip their navies with state-of-the-art submarines in a context of heightened global competition, where the covert capabilities inherent to this kind of platform are seen as extremely valuable.

At a global level, much like space, the underwater dimension is becoming increasingly competitive, contested and to some extent congested. As such, it presents distinct challenges not only for navies, but indeed for the combination of military and civilian, public and private entities that operate in this environment.

Uncrewed underwater vehicles: Opportunities and challenges

In order for UUVs to become a truly game-changing asset in military operations and avoid the constraints of tethering, a large degree of autonomy will have to be achieved to minimise the need for wireless information exchanges. While some concepts mixing cable-directed and autonomous guidance have been floated, most of the recent efforts pertaining UUVs revolve around autonomous underwater vehicles. As a consequence, UUVs are increasingly being employed for missions outside of their more traditional de-mining and exploration roles.

In particular, increased range has sparked discussions about the integration of undersea drones in tasks such as anti-submarine warfare (ASW) or even the creation of underwater anti-access/area denial (A2/AD) bubbles. Nevertheless, while operating at depth UUVs still face some of the same challenges as manned submarines, such as hampered communication and difficulties in detecting

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

enemies and allies alike with passive sensors in the vastness of global oceans.

Russia is among the global powers that has invested the most in the development of UUVs. More broadly, the last five years have seen worldwide interest in experimenting the development of larger UUVs, especially for countries with an oceanic perspective such as the US, the UK, China, France and Australia.

An overview of the European context

Although by and large European countries appear to lag behind the state of the art in terms of seabed warfare and UUV technology and integration, the continent's main naval powers have traditionally been at the forefront of submarine technology.

The UK's 2022 Maritime Security Strategy highlights the necessity of defending critical seabed infrastructures such as gas pipelines and cables. Moreover, an ongoing review of the Royal Navy's fleet balance suggests that submarines may play an ever-growing role in Britain's force structure. London is currently carrying out a comprehensive update of its submarine fleet, while prioritising the full modernisation of the British nuclear ballistic missile submarines (SSBN). At the same time, a reflection has already started on the successors of the existing generation of submarines, with an obvious view to AUKUS.

Like the UK, France is not shy about its capabilities in the underwater domain, which is considered crucial for its power projection both in the conventional and nuclear arenas. In 2022, France's minister of Armed forces presented the nation's first seabed strategy (*Stratégie ministérielle de maitrise des fonds marins*), introducing some innovation to how the Marine Nationale looks at the underwater domain. At the same time, the debates about the return of high-intensity warfare as a combat scenario has opened some new questions about the size of the *Forces sous-marines* and the prioritisation of nuclear-powered attack submarine (SSN) over SSBNs.

Sweden is among the few Western countries with recent experience in large-scale ASW operations, although not in an active conflict. With Russia's aggressive posture in Europe and the sabotage of Nord Stream 1 and 2 pipelines a few miles from its shores, the regional security environment is likely to deteriorate further over the next years. Yet, despite being at the forefront of conventional propulsion attack submarines (SSK) technology, Sweden's modernisation efforts have been met with some difficulties over the last decades. In this context, Sweden is trying to invest in the development of a next-generation submarine capability, while providing stopgap solutions for the next decade.

Spain is the latest European country to have developed an indigenous submarine system for its navy. The new S-80+ class will be the first foray into a completely national class for Spain in decades, though its development and entry into service have proven particularly difficult. Concerning UUVs, the Barracuda programme, launched in 2019, is meant to substitute the Armada's remotely operated underwater vehicle (ROUV) with AUVs for mine countermeasures (MCM) purposes, while plans also exist pertaining further purchase of drones.

The European Union has recognised the economic and military importance of the underwater domain, as well as the vulnerability of UCIs. In the most recent update of the EU Maritime Security Strategy (EUMSS), the EU Commission addresses the impact of current technological advancements. The EU has also provided direct financing to numerous underwater-related initiatives, such as OCEAN 2020 and a number of projects in the context of the European Defence Fund (EDF) and its precursor programmes.

NATO too plays an important role in spurring international cooperation in the underwater domain, in particular in terms of Standardisation Agreements (STANAG) when it comes to UUVs. The Alliance can also count on some relevant joint initiatives, including the Centre for Maritime Research and Experimentation (CMRE) in La Spezia and the Kiel-based Centre of Excellence for Operations in Confined and Shallow Waters (CoE CSW). After the Nord Stream 1 and 2 sabotage, upon request of Germany and Norway, the Alliance has also established a coordination cell tasked with mapping vulnerabilities and coordinating efforts among NATO Allies and partner countries.

Germany

Germany is considered a world-leading player when it comes to the underwater domain and has featured prominently in this segment for more than a century, with German-made SSKs dominating international markets. Its companies, from shipbuilders such as ThyssenKrupp Marine Systems (TKMS) to suppliers of electronic components, play a major role in the research and production of new submarine classes. This puts German know-how, technologies and production industrial capacities at the forefront of the global race to acquire new and modern capabilities in the underwater domain. The recent proliferation of UUVs and the attacks on the Nord Stream pipelines have contributed to a renewed interest in military operations below the surface are indicative of the challenges the German Navy and industry will have to face.

The 2023 defence budget does not foresee any new procurement project for the underwater domain. Still, expenditures for the upcoming U121CD-class submarines and the purchase of IDAS air defence systems for submarines will be financed via the 100-billion-euro Special Fund for the Armed Forces set up in the wake of Chancellor Scholz's *Zeitenwende*. The expected adjustments will also affect current fleet structures and balance.

Reflections are ongoing on a potential expansion of Germany's UUVs fleet for MCM tasks, with a further addition of six large-sized UUVs (LUUVs) for reconnaissance missions also mentioned as an objective. The Planning Office of the Bundeswehr has articulated its own strategic and technical outlook on the matter of UUVs already in a 2017 report, which formulates its expectations on the development of

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

such systems. In the short term, the Bundeswehr does not envisage any major role for UUVs beyond oceanographic mapping and MCM.

The Indo-Pacific and the underwater environment

The Indo-Pacific's security environment is characterised by the rise of China and its military capabilities, the tensions about the status of Taiwan, and a concurrent general drive by most regional countries to bolster their militaries through the acquisition of equipment across the board, with particular attention to the maritime domain. In a high-intensity conflict scenario sparked by a Chinese aggression, in the Taiwan Strait or the South China Sea, submarines could play a decisive role.

While historically China has lacked cutting-edge underwater capabilities, a very significant drive is ongoing in order to turn the country into a leading power beneath the surface. The People's Liberation Army Navy (PLAN) has at its disposal a large and growing fleet composed of SSKs, SSNs and SSBNs, which according to estimates could reach a total number of 76 units in service by 2030. However, amid a staggering shipbuilding effort both in terms of sheer numbers and quality of the newly launched surface ships, the PLAN is simultaneously prioritising the modernisation of its submarine force rather than a radical growth in numbers. As it pushes to become a more significant underwater player, Beijing is also putting efforts into building solid UUV capabilities and already operates the largest and most active fleet of hydrographic survey ships in the Indo-Pacific.

Elsewhere in the region, Japan and South Korea are veritable submarine force heavyweights, with 22 and 20 active units respectively, all conventionally powered. South Korea has recently become one of the few countries world-wide to have exported submarines, with a domestic industry building vessels largely based on German designs. Meanwhile, Japan's submarine fleet is simultaneously large and exceedingly 'young' on average – as Tokyo prefers to build new submarines than to modernise in service ones – backed by highly advanced industrial capabilities. Both countries are making substantial investments on the use and integration of UUVs, in some cases showing high levels of ambition compared to many Western counterparts.

Through AUKUS, Australia is presented with a capability that will revolutionise its deterrence outlook in the Indo-Pacific vis-à-vis China, giving its future submarine force unprecedented range, speed, and offensive capabilities, especially when considering the vast distances that would characterise any naval conflict taking place in the region. UUVs are mentioned as a priority in the 2023 Defence Strategic Review, and Australia is running a programme for the development of extra-large UUVs (XLUUV) known as Ghost Shark.

Southeast Asia is an increasingly prominent market for defence exports when it comes to underwater capabilities. The four largest littoral states - Indonesia, Malaysia, Vietnam and the Philippines – have to different extents been modernising their navies while also focusing on enhancing (or, in the case of the Philippines, building for the first time) their submarine capabilities. Indeed, many conventional submarine-producing countries will be looking at this region with interest, hoping to strike deals for their domestic industries.

The Italian approach to the underwater domain

Thanks to its location at the very centre of the Mediterranean, Italy is by nature a commercial and, potentially, energy hub in the region. As cables and pipelines become crucial arteries for the functioning of the global economy, the UCI become even more important for the country's national interests and security. Southern Italy is already a bridge to gas-producing countries thanks for an array of infrastructures that have become much more critical to Italy's economy since the Russian invasion of Ukraine in February 2022 and the subsequent diversification efforts away from Russian gas and towards suppliers in the wider Mediterranean.

From a defence perspective, the underwater dimension, spanning from just below the surface to the seabed, is now seen by the Italian Navy (*Marina Militare Italiana* – MMI) as the fifth physical operational domain, beside air, land, maritime and space. Therefore, the MMI believes operating underwater requires renewed attention, a novel doctrinal approach, as well as peculiar skills and technological solutions, especially considering that the use of UUVs has pushed the boundaries in terms of how deep navies as well as private actors can operate.

According to the MMI, the first necessary step is the pursuit of an adequate underwater situational awareness, a concept similar to those applied to the other operational domains but more difficult to implement due to the aforementioned physical and technological constraints in this environment. The awareness that innovation as well as security in the underwater domain depend not only on military actors but also on civilian and private entities has motivated Rome to institute the new National Underwater Hub (*Polo nazionale della dimensione subacquea* – PNS) in La Spezia. The PNS aims to become a forum where universities, research centres, start-ups, small and medium-sized enterprises, large companies, the navy and other institutional stakeholders work together to create favourable conditions for innovation, the creation of know-how and the development of technologies.

When it comes to submarines, Italian ambitions and priorities in the underwater domain have led to the decision to pursue the next procurement programme on a national basis, by realising the U212 Near Future Submarine (NFS). The NFS will build upon previous cooperation with Germany to supply the MMI with a state-of-the-art submarine with a higher share of Italian technology on board.

Italy's underwater technological and industrial capabilities

The Italian defence and shipbuilding industry is experiencing important developments in terms of underwater technologies. The design and construction of the U212 NFS can be assessed as a real leap forward for several Italian companies involved in the underwater domain, *in primis* Fincantieri. Such a leap has paved

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

the way for the relaunch of an Italian underwater industrial cluster, which includes large companies and several small and medium-sized enterprises (SMEs). Its output, mainly aimed at satisfying the Italian Navy's requirements, has remarkable applications to civilian tasks such as, inter alia, search and recovery of submerged objects, environmental assessment, seabed survey for commercial exploitation.

Conversely, in some cases, technologies and systems conceived for the civilian market, notably in the context of the offshore oil & gas industry, are being exploited for or adapted to underwater military applications. The same is true also for UUVs, and their associated support systems (including launch and recovery and command and control) used for underwater military operations.

Although the Italian industrial underwater cluster is heavily committed in satisfying many of the Navy's operational requirements, and there is a growing degree of autonomy relating to a number of technologies concerning to lithium batteries, electronic warfare, combat management systems, integrated platform management systems and torpedoes, there are still some capability gaps to fill for which Italy has to rely on foreign know-how and procurement.

Against this backdrop, the study's conclusions focus on three main elements:
1. Critical infrastructures: a public-private partnership
2. Submarines: managing industrial competition and military cooperation
3. UUVs: European cooperation and a novel approach.

In particular, six elements are key for Italy:
1. more attention to the underwater domain within a coherent Ministry of Defence posture
2. the NFS as catalyst for innovation
3. the diversification of submarine markets and the opportunity of smaller platforms
4. a leading role and a pooling of investments on UUV and AI
5. a renewed approach to UCI surveillance and protection
6. an effective *Polo nazionale della dimensione subacquea*.

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

1. The underwater domain

by Elio Calcagno

For much of recorded history, humankind has relied heavily on sea and inland waterways to conduct trade and harvest food and resources. Yet the global economy has never been more reliant on the sea than today, making the maritime space a hotly contested space, where well-established and rising powers alike are working on increasing their own military capabilities. Technological advancements in the field of uncrewed underwater vehicles (UUVs) and especially recent breakthroughs in the field of autonomous underwater vehicles (AUVs) have contributed to making underwater critical infrastructures (UCI) such as telecommunications cables and oil and gas pipelines more vulnerable to disruption, sabotage, or broadly speaking military action. As a result, navies cannot avoid grappling with the concept of seabed warfare and develop new doctrines and requirements accordingly. At the same time, the field of submarine warfare is experiencing a renaissance of sorts, with more countries then ever looking to equip their navies with state-of-the-art submarines in a context of heightened global competition, where the covert capabilities inherent to this kind of platform are seen as extremely valuable. Much like space, the underwater dimension is becoming increasingly competitive, contested and to some extent congested, and represents a distinct challenge not only for navies, but indeed for the combination of military and civilian, public and private entities that contribute to pursuing any country's economic and strategic interests.

1.1 The technological challenges of underwater operations and seabed warfare

Operating underwater requires mastering technological solutions to the extremely high pressures that characterise deep water environments. Here, humans are in a way the weakest link and thus crewed assets like submarines are first and foremost designed to work as protective shells. Secondly, technology relating to propulsion and energy storage, especially with regard to conventionally powered submarines and UUVs, has to contend with extremely limited space for batteries or the need for air in order for diesel engines to recharge them. Thirdly, and crucially, the physical properties of water make well-established methods of wireless communication commonly used on the surface, in the air and in space an unviable or sub-optimal solution for underwater communications. This also includes Global Positioning System (GPS) or other satellite-based navigation systems, meaning that submarines largely rely on inertial navigation systems in order to obtain acceptably-precise estimates of their location: a pre-requisite for modern submarine operations.[1] Indeed, only very low frequency (VLF) and extremely low frequency (ELF) radio waves can penetrate water for very limited distances and with data bandwidths

[1] Dorian Archus, "How Do Submarines Navigate Underwater?", in *Naval Post*, 13 May 2021, https://navalpost.com/?p=26090.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI

ISSN 2280-6164

greatly diminished by the low frequencies.[2] In an operational scenario, VLF requires a submarine to ascend near the surface and deploy a buoy that reaches even shallower depths to receive any usable signal. In turn, the data must be compressed by the sender and be as simple as possible to minimise transmission times and thus the time a submarine must spend at lower depths – where there is a higher risk of detection – while receiving messages. ELF, on the other hand, can reach submarines at much higher depths, diminishing exposure times, but is even more limited in bandwidth and, consequently, message complexity. For submarines and underwater vehicles, both VLF and ELF are a one-way communication system where radio waves can only be received, as the transmitters needed to transmit data at these frequencies require large amounts of energy that are beyond the capabilities of submarines' on-board systems.[3]

UUVs offer several potential solutions to the limitations of wireless underwater communication, while still suffering for weaknesses of their own. For instance, tethered uncrewed vehicles, or remotely operated underwater vehicles (ROUVs), can be controlled in real time and allow for high-bandwidth data transfers, they are limited in range and manoeuvrability by the very cables by which they are able to communicate with their controllers.[4] In addition, in offensive scenarios, the very existence of a 'mother ship' hovering above a tethered vehicle essentially annuls the ability of operating stealthily.[5]

New technological advancements related to robotics, artificial intelligence, data processing and computing have only recently started to unlock the potential of AUVs in the underwater environment. Indeed, autonomous vehicles are in the process of greatly diminishing the efficacy of the natural defence barrier that water and depth historically provided to undersea infrastructure. Equally, this technology is set to present operators (both civilian and military) with great opportunities and threats alike as they expand their operational limits downward with a view to seabed warfare, which is a type of military operations that focuses on the sea and ocean floor[6] – where a considerable number of critical infrastructures lie.

1.2 Submarine cables and pipelines: the world's neurovascular system

Despite the newly acquired salience of undersea cables and pipelines in the public debate, this type of infrastructure has been in use for at least three quarters of a century. Indeed, the first underwater telegraph cable was laid in 1850 between UK and France,[7] whereas the first underwater oil pipeline was laid down across

[2] Carlos A. Altgelt, *The World's Largest "Radio" Station*, 2014, https://pages.hep.wisc.edu/~prepost/ELF.pdf.

[3] Ibid.

[4] Interview, 8 March 2023.

[5] Fore an in-depth discussion on UUVs, ROUVs and AUVs see chapter 2 of this study.

[6] Ibid.

[7] "Undersea Cable", definition in *Encyclopedia Britannica*, https://www.britannica.com/technology/

the English Channel as part of "Operation PLUTO" in order to support the Allied advance against Nazi Germany with a steady supply of oil.[8] While both cables and pipelines have always presented some degree of vulnerability near the coastal areas in shallow waters or indeed where they made landfall, depth has historically been their best defence.

Today, between 97 and 99 per cent of global internet traffic relies on over 400 fibre optic underwater cables, spanning a total of more than 1 million kilometres.[9] This cable infrastructure is as vital to the correct functioning of the global economy as it is difficult to monitor persistently.[10] Moreover, while mostly ignored by media headlines, cables are used to transfer large amount of electricity across the sea, as is the case in Italy between the mainland and its major islands.[11]

The underwater domain is also where part of the extraction, processing, and transportation of oil and gas products occurs, given that ca. 30 per cent of oil and gas globally is extracted by offshore fields. Moreover, a significant share of all oil and gas extracted on and offshore will transit undersea pipelines or sea-based infrastructure at some point before reaching the consumer.[12] In a way, given the utmost importance that telecommunications and fossil fuels play in human development and the functioning and growth of the global economy, it can be said that undersea cables and pipelines are truly the world's metaphorical neurovascular system.

The discovery of rare raw materials in the seabed is also opening new frontiers concerning deep-seabed mining,[13] potentially adding a new layer to the territorialisation of the sea through the unilateral declaration of exclusive economic zones (EEZs), a phenomenon we are already witnessing in the context Mediterranean basin. The growing role that aquaculture farms are playing in providing nutrition across the world only add another layer to discussions revolving around potential disruption of sea-based infrastructures.[14]

undersea-cable.

[8] Bruce A. Wells and K.L. Wells, "PLUTO, Secret Pipelines of WW II", in *American Oil & Gas Historical Society website*, last updated on 3 June 2023, https://aoghs.org/?p=42279.

[9] These cables are estimated to carry 10 trillion US dollars' worth of financial transactions every day. See: Charlie Cooper, "NATO Warns Russia Could Target Undersea Pipelines and Cables", in *Politico*, 3 May 2023, https://www.politico.eu/?p=2996754.

[10] Fondazione Leonardo and Italian Navy, *Civiltà del mare. Geopolitica, strategia, interessi nel mondo subacqueo. Il ruolo dell'Italia*, 7 March 2023, https://www.civiltadellemacchine.it/documents/14761743/0/Rapporto_Civilt%C3%A0+del+Mare.+Geopolitica%2C+strategia%2C+interessi+nel+mondo+subacqueo.pdf.

[11] Ibid.

[12] Jeremy Cresswell, "Future Looks Bright for Global Subsea Engineering", in *Energy Voice*, 5 February 2019, https://www.energyvoice.com/?p=191951.

[13] Robin McKie, "Deep-Sea Mining for Rare Metals Will Destroy Ecosystems, Say Scientists", in *The Guardian*, 26 March 2023, https://www.theguardian.com/p/ntqzg.

[14] Robert Jones, Bill Dewey and Barton Seaver, "Aquaculture: Why the World Needs a New Wave of Food Production", in *World Economic Forum Articles*, 28 January 2022, https://www.weforum.org/

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI

ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023

The sabotage in September 2022 of the Nord Stream 1 and 2 pipelines, which were built to transport gas from Russia to Germany directly through the Baltic Sea, was a stark reminder of the vulnerability of UCIs at a time of heightened tensions and competition across the globe. Crucially, the incident also shed a light onto the difficulties inherent to attributing an underwater sabotage to any one actor,[15] despite the explosions occurring no deeper than 90 metres from the surface and in a crowded stretch of sea.[16] The uncertainty surrounding who exactly would have had the means and motives to carry out such an operation also served to show how effective attacks on UCIs can be in a grey zone scenario, where disinformation and propaganda in the absence of hard evidence can be harnessed to achieve certain goals.[17] The huge and growing importance of underwater pipelines and cables make them a valuable target for hostile actors, and a new soft spot to be protected.

1.3 Protecting underwater critical infrastructure

Among major naval powers, Russia appears to be the one to have invested the most in seabed warfare capabilities.[18] Moscow has at its disposal a few very large "special missions" submarines designed or modified to carry and launch smaller deep-diving nuclear-powered so-called 'midget' submarines, designed specifically for seabed operations (one of these has been reported to have dived as deep as 2,000-2,500 metres).[19] The latest and most modern of Russia's special missions units, the Belgorod, is based on the Oscar-II ballistic missile nuclear-powered submarine (SSBN) and has entered service in 2022.[20] Moscow has also invested in the *Yantar*, a surface ship labelled officially as an oceanographic vessel, though it is believed to be specialised in surveying and perhaps tapping and disrupting underwater cables, while also being capable of deploying small crewed underwater vehicles as well as ROUVs.[21]

The fact that Russia has undertaken such an effort in developing technologies directly aiming at UCI disruption and seabed warfare points to the strategic importance that scenarios of this type have gained in Russian strategic thinking. Rather tellingly, Moscow typically operates such capabilities under the Main

agenda/2022/01/aquaculture-agriculture-food-systems.

15 Charlie Cooper, "Swedish Investigators: 'Difficult' to Confirm Who Blew up Nord Stream", in *Politico*, 6 April 2023, https://www.politico.eu/?p=2879817.

16 Kate Connelly, "Size of Nord Stream Blasts Equal to Large Amount of Explosive, UN Told", in *The Guardian*, 30 September 2022, https://www.theguardian.com/p/mc26a.

17 Charlie Cooper, "Who Blew up Nord Stream?", in *Politico*, 8 March 2023, https://www.politico.eu/?p=2744649.

18 For an analysis on Russian investment in UUVs specifically, see chapter 2 of this study.

19 H.I. Sutton, "Russia's New Super Submarine, Belgorod (K-329)", in *Covert Shores*, 29 June 2021, http://www.hisutton.com/Belgorod-Class-Submarine.html.

20 H.I. Sutton, "5 Ways the Russian Navy Could Target Undersea Internet Cables", in *Naval News*, 7 April 2021, https://www.navalnews.com/?p=20929.

21 H.I. Sutton, "Russian Ship Loitering Near Undersea Cables", in *Covert Shores*, 13 September 2017, http://www.hisutton.com/Yantar.html.

Directorate for Deep Sea Research (GUGI) rather than the navy – a policy that potentially places their legal status within the grey zone spectrum.[22]

Cables, pipelines, offshore fields, installations, and any critical infrastructure based at sea are all vulnerable to kinetic attacks, while telecommunication cables are susceptible to tapping. Tapping is a particularly difficult activity and, in the age of the internet, could aim to intercept or disrupt data flows.[23] While tapping attempts could also target onshore landing stations for the cables, the cover of depth presents an opportunity to tap cables directly on the sea bottom.[24]

The opacity of the sea makes detecting and identifying threats difficult until disruption has been successful, and responsive kinetic action against such threats may not happen before the damage is done. Therefore, prevention and redundancy appear to be the first and most effective line of defence against potential attacks.[25] The sabotage of the Nord Stream pipelines and subsequent spike of activities by Russian vessels in the proximity of UCIs, including cables, pipelines, and wind farms in the North Sea have in many ways highlighted the challenges in protecting such assets effectively simply by bolstering a conventional naval presence in the interested areas.[26] First of all, UCI networks are constantly expanding and already so extensive that it is virtually impossible to guarantee the persistent naval presence needed to monitor them effectively for long periods of time. Indeed, NATO has acknowledged the sheer scale of the challenge by establishing a new cell in Brussels directly tasked with mapping vulnerabilities coordinating efforts among NATO Allies and partner countries but also, importantly, the private sector and UCI operators.[27]

Ideally, in the future, the protection of UCIs could be based in large part on combining data and analysis from a variety of sources such as Automatic Identification System (AIS),[28] satellite-based sensors and terrestrial radars for

[22] Johannes Peters, "Below the Surface: Undersea Warfare Challenges in the 21st Century", in Julian Pawlak and Johannes Peters (eds), *From the North Atlantic to the South China Sea. Allied Maritime Strategy in the 21st Century*, Baden-Baden, Nomos, 2021, p. 93-110, https://www.nomos-elibrary.de/10.5771/9783748921011-93/below-the-surface-undersea-warfare-challenges-in-the-21st-century.

[23] Tapping underwater cables is nothing new. During the Cold War, for instance, the US was able to tap a Soviet communications undersea cable off the coast of Kamchatka. See: Caleb Larson, "How a US Navy Submarine Secretly Tapped Russia's Undersea Cables", in *The Buzz*, 26 July 2021, https://nationalinterest.org/node/190478.

[24] Colin Wall and Pierre Morcos, "Invisible and Vital: Undersea Cables and Transatlantic Security", in *CSIS Commentaries*, 11 June 2021, https://www.csis.org/node/61226.

[25] Pete Barker, "Undersea Cables and the Challenges of Protecting Seabed Lines Communication", in *Seabed Warfare Week*, 15 March 2018, https://cimsec.org/?p=35889.

[26] Fabio Indeo, "NATO and the Protection of Critical Energy Infrastructure", in *NDCF Food for Thought*, 24 October 2022, https://www.natofoundation.org/?p=38750.

[27] NATO, *NATO Secretary General Engages Industry on Critical Undersea Infrastructure*, 5 May 2023, https://www.nato.int/cps/en/natohq/news_214322.htm.

[28] AIS is a tracking system for surface ships. International Maritime Organization (IOM) guidelines dictate that ships may never switch their AIS off when underway or at anchor. Ships carrying out

ISSN 2280-6164

surface surveillance, and underwater sensors (including active and passive sonars and cameras) mounted directly on the UCIs themselves or carried by UUVs for underwater surveillance.[29] Indeed, while the fusion of heterogeneous data with the aim of building a recognised maritime picture on the surface is already a well-established – but still challenging – practice thanks to a number of initiatives such as, in the EU context, the Critical Maritime Routes Indo-Pacific (CRIMARIO) and Maritime Surveillance (MARSUR) projects, the identification of surface-level patterns useful to the surveillance and protection of UCIs will greatly benefit from the opportunities offered by artificial intelligence (AI) and machine learning.[30]

Under the surface, however, any attempt at creating a persistent underwater surveillance capability feeding from multiple sources, including UUVs and UCI-based sensor networks, is complicated by the difficulty in establishing a permanent and pervasive underwater presence. At a minimum, a high degree of cooperation among military and civilian operators in order to define safety and redundancy requirements is a necessary starting point. At the same time, the ability to operate underwater is going to play a major role in the UCI protection too.

1.4 The renaissance of submarines

With the return of deterrence high on major powers' agendas, the territorialisation of the world's seas and oceans, the aforementioned importance of UCIs, as well as a growing sense of insecurity perceived globally, the submarine is experiencing a kind of renaissance both in terms of technological advancements and surging market demand. Submarines are a unique asset in a navy's fleet as they provide unparalleled stealth and survivability thanks to the capacity to operate under the cover of deep water for extended periods of time.

After a relative post-Cold War hiatus in investment and total in-service numbers,[31] the global submarine market is estimated to grow about 50 per cent in the next decade from a total value of 30 billion US dollars in 2023 to 45.6 billion in 2033.[32] From the Indo-Pacific to the Middle East and North Africa, most countries that are able to afford submarines either already operate them, are in the process of procuring more, or indeed are purchasing them for the first time.[33]

illegal or covert activities usually switch AIS off to avoid being tracked. See: NATO Shipping Centre, "AIS (Automatic Identification System) Overview", in *NSC News*, 22 October 2021, https://shipping.nato.int/nsc/operations/news/2021/ais-automatic-identification-system-overview.

[29] Giovanni Soldi et al., "Monitoring of Underwater Critical Infrastructures: the Nord Stream and Other Recent Case Studies", in *arXiv*, 3 February 2023, https://doi.org/10.48550/arXiv.2302.01817.

[30] Ibid.

[31] James Clay Moltz, "Global Submarine Proliferation: Emerging Trends and Problems", in *NTI Reports*, 31 May 2006, https://www.nti.org/?p=21189.

[32] "Global Submarine Market to Surpass $45 Billion in 2033", in *Defence Review Asia*, 17 April 2023, https://defencereviewasia.com/?p=11248.

[33] Aaron Beng, "Submarine Procurement in Southeast Asia: Potential for Conflict and Prospects for Cooperation", *Pointer: Journal of the Singapore Armed Forces*, Vol. 40, No. 1 (2014), p. 55-66, https://www.mindef.gov.sg/oms/content/dam/imindef_media_library/graphics/pointer/PDF/2014/

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

Up until AUKUS,[34] virtually all new or emerging submarine operators were relying on conventional propulsion, diesel-electric attack submarines (SSKs). Nuclear-powered submarines, on the other hand, have been in service with very few countries world-wide, namely the US, Russia, China, France, the UK, and more recently India. Brazil has an ongoing nuclear-powered attack submarine (SSN) programme and Australia is set to acquire this capability within the next two decades.[35]

Conventional propulsion entails certain disadvantages in comparison with nuclear one, related mainly to the slower top speeds, limited underwater range and necessity to resurface frequently in order to recharge the batteries with a diesel motor that needs access to air in order to suck in oxygen and dispose of combustion waste gases.[36] During the last two decades, however, technological advances in conventional propulsion have significantly enhanced the performance of diesel-electric submarines, starting with air-independent power (AIP) technology, which is added on top of batteries and diesel engines. AIP technology still has some limitations: for instance, the fuel cells equipped on the Type U212 need oxygen and hydrogen to function, meaning that the AIP power unit does not have unlimited endurance. Yet, the improvement over older technologies is very significant: AIP units have increased the underwater range of newer submarines to up to three weeks, as is the case for the German-Italian Type U212A, which rely on fuel cells technology.[37] On the other hand, traditional SSKs are only equipped with batteries and diesel engines to re-charge them, which require the vessel to emerge at periscope level at regular intervals to acquire oxygen through a special snorkel. AIP-capable submarines are also quieter than conventional diesel-electric units, a quality that combined with longer submerged endurance makes them generally the stealthiest option.[38] More recently, Japan was the first to introduce the use of lithium-ion batteries on submarines, which should last longer and need less maintenance than the traditional lead-acid batteries still powering most conventional submarines, and this represent a further improvement of non-

Vol.40%20No.1/7)%20V40N1_Submarine%20Procurement%20in%20Southeast%20Asia%20Potential%20for%20Conflict%20and%20Prospects%20for%20Cooperation.pdf; Japan's Ministry of Defense, *2020 Defense of Japan*, Tokyo, November 2020, p. 134-141, https://www.mod.go.jp/en/publ/w_paper/wp_2020.html.

[34] Elio Calcagno, "Aukus: il fronte anglosassone nel Pacifico che esclude la Francia", in *AffarInternazionali*, 22 September 2021, https://www.affarinternazionali.it/archivio-affarinternazionali/?p=89353.

[35] For an analysis of AUKUS and what it entails for Australian SSN capabilities, see chapter 5 of this study.

[36] Michael Walker and Austin Krusz, "There's a Case for Diesels", in *USNI Proceedings*, Vol.144/6/1384 (June 2018), https://www.usni.org/node/33210.

[37] Giunio G. Santi and Francesco Popia, "The Promise of Better Submarine Air-Independent Propulsion", in *USNI Proceedings*, Vol. 147/3/1417 (March 2021), https://www.usni.org/node/55724.

[38] Sebastien Roblin, "Air Independent Propulsion Could Create Silent Killer Submarines", in *The Reboot*, 27 August 2021, https://nationalinterest.org/node/192514.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

nuclear propulsion.[39]

However, as is the case for many military technologies, any comparison with potential counterparts must take into account the operational scenarios in which they are required to operate. As such, conventional submarines are generally smaller and more manoeuvrable while often being quieter than nuclear boats when they are submerged and operating on batteries or AIP.[40] On the other hand, nuclear submarines' submerged range is limited exclusively by the need to restock supplies and rotate crews. In the case of SSNs, top speeds comparable to aircraft carriers and major surface combatants make them well-suited to operate as part of carrier group escorts or indeed to hunt enemy ships. It is no surprise that, for a handful of countries, SSBNs are perhaps the most crucial component of the nuclear triad, as they are able to spend months while moving submerged in order to guarantee a resilient and elusive second-strike capability.

In essence, nuclear-powered submarines are the ideal platform for global force projection and those navies tasked with patrolling great distances and discretely tracking adversary naval vessels. Unsurprisingly, the greater speed and endurance have been cited by the Australian government as some of the principal reasons for turning to the US and UK for the acquisition of SSNs in the next decades, with the stated goal of facing the growing Chinese threat in the Indo-Pacific.[41]

While the increasing performance of diesel-electric submarines still cannot match that of nuclear-powered ones in absolute terms, it is clear that the longer underwater range of the most modern units is granting many navies unprecedented potential not only in anti-access/area denial (A2/AD) scenarios, but also to a degree in terms of force projection, especially considering that many navies are either planning to equip, or currently equipping, conventional submarines with anti-ship and deep strike cruise missiles.[42]

While demand for state-of-the-art conventional submarines is soaring worldwide, only a few countries' defence industries are able to muster enough technological know-how to design and build conventional submarines. Among these, France, Germany, Italy, the Netherlands, Japan, South Korea, Spain, and Sweden are already well-established players, while Taiwan and Turkey are currently working on indigenous designs for the first time, with the latter planning to begin construction

[39] Eric Wertheim, "Japan's Advanced Lithium-Ion Submarines", in *USNI Proceedings*, Vol.148/12/1438 (December 2022), https://www.usni.org/node/59186.

[40] Michael Walker and Austin Krusz, "There's a Case for Diesels", cit.

[41] Kirsty Needham, "Analysis: Nuclear Submarine Plan Aims to Give Australia Strategic Edge to Deter China", in *Reuters*, 10 March 2023, https://www.reuters.com/world/nuclear-submarine-plan-aims-give-australia-strategic-edge-deter-china-2023-03-10.

[42] The Norwegian navy is planning to equip its future submarines with naval strike missiles, while the Italian navy is set to equip its U212 NFS with deep strike capabilities. Algeria's Russian-made Kilo-class submarines are equipped with Club-S versions of the Kalibr cruise missile.

of the first domestically designed *Milden*-class submarine by 2025.[43]

Current trends suggest that despite high development costs and the increasing complexity of these platforms, countries that once relied on industrial cooperation with partners or used the domestic industry to build foreign designs are now looking to go down a different route by implementing new, national programmes. This has recently been observed in the European context, for instance in the case of Italy and Spain, which are aiming to bolster the respective defence technological and industrial bases (DTIBs) while also attempting to enter an export market which promises to become more and more competitive in coming decades.

[43] H.I. Sutton, "Countries that Can Design and Build Submarines Today", in *Covert Shores*, 9 March 2023, http://www.hisutton.com/Submarine-Building-Countries-List.html; Tayfun Ozberk, "First Details on Turkiye's Future MILDEN Submarine", in *Naval News*, 30 August 2022, https://www.navalnews.com/?p=37004.

ISSN 2280-6164

2. Uncrewed underwater vehicles: Opportunities and challenges

by Michelangelo Freyrie[1]

2.1 Technological innovation

The term "underwater uncrewed systems" is used to identify both AUVs and ROUVs. The distinction between these two types of UUVs does not only consist in the degree of autonomy with which they perform basic tasks – such as navigating between two pre-set points – but also in the way in which the drones communicate with its control station. Namely, ROUVs are typically tethered to a submarine or some other controlling asset, which limits their potential range to the length of the tethers. Still, tethered vehicles carry the significant advantage of being able to transmit a large amount of data without the physical constraints imposed by wireless communications in a body of water. Conversely, the most widely used wireless technology in this field, VLF and ELF, can only transmit a modest amount of data below periscope level.[2]

In order for UUVs to become a truly game-changing asset in military operations and avoid the constraints of tethering, a large degree of autonomy will have to be achieved in order to minimise the need for wireless information exchanges.[3] While some concepts mixing cable-directed and autonomous guidance have been floated, most of the recent efforts pertaining UUVs revolve around AUVs.[4] As a consequence, UUVs are increasingly being employed for missions outside of their classical mine countermeasures (MCM) and exploration roles. Technological leaps have made long range autonomous navigation more viable, granting UUVs a growing level of persistence.[5] The increasing power of semiconductors and the introduction of limited AI functions, as well as increasingly complex algorithms, also allow UUVs to elaborate a larger array of data, crucial in providing the necessary processing power for more autonomous capabilities. This may seem trivial, but such innovation should not be underestimated given the complex nature of the underwater environment, which makes it significantly more difficult to navigate than the air given natural and artificial obstacles, fauna and much more.[6]

[1] Michelangelo Freyrie is a Junior Researcher in the Defence and Security Programmes at IAI.

[2] Ian F. Akyildiz, Dario Pompili and Tommaso Melodia, "Challenges for Efficient Communication in Underwater Acoustic Sensor Networks", in *ACM Sigbed Review*, Vol. 1, No. 2 (July 2004), p. 3-8, https://doi.org/10.1145/1121776.1121779.

[3] Interview, 6 March 2023.

[4] Interview, 8 march 2023.

[5] GlobalData Thematic Intelligence, "Unmanned Underwater Vehicles: Defence and Technology Trends", in *Naval Technology*, 9 September 2021, https://www.naval-technology.com/?p=64127.

[6] Agus Budiyono, "Advances in Unmanned Underwater Vehicles Technologies: Modeling, Control and Guidance Perspectives", in *Indian Journal of Marine Sciences*, Vol. 38, No. 3 (September 2009), p. 282-295, https://nopr.niscpr.res.in/handle/123456789/6204.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

The underwater environment is subject to a number of constrains that have limited the proliferation of UUVs. The aforementioned limits imposed by water on untethered communications (and despite research into underwater line-of-sight communication)[7] also prevent the establishment of satellite links. These restrictions mean that, unlike in the air domain, swarming still remains a great challenge at the current technological level.[8]

With this in mind, quantum computing is the current emerging disruptive technology (EDT) from which UUV development stands to profit the most. The multiplication of computing power enabled by quantum architectures could, for instance, allow UUVs to calculate geographical positioning without connecting to a satellite-based system such as GPS.[9] Producers of high-end inertial sensor systems are mostly located in Europe and North America, and many entities – such as Germany's iMAR or Beihang University in China – have received public funding to pursue applications of quantum computing in this sector.[10] This would solve one of the main issues pertaining underwater vehicles, which need to rise to periscope level at regular intervals to confirm their precise location.

The growth in computing power has been accompanied by other trends. As observed in other naval systems, UUVs are becoming increasingly multifunctional, thanks in part to the appearance of medium, large and extra-large-sized UUVs (respectively MUUV, LUUV and XLUUV), which are also deemed more suited to a modular payload architecture than smaller vehicles.[11] Moreover, higher-quality sonars and investment in manned-unmanned teaming (MUM-T) research have also allowed to integrate UUVs in operational concepts that go well beyond de-mining operations in shallow waters.

2.2 Operational perspectives

Technological innovation has already broadened the operational horizons of UUVs, which in certain operational scenarios could potentially substitute human beings in an extremely dangerous natural domain, characterised by extreme water pressure and low visibility.[12] Increased range has sparked discussions about the integration of undersea drones in tasks such as anti-submarine warfare (ASW) or

[7] Forest B. Mclaughlin, *Undersea Communications between Submarines and Unmmaned Undersea Vehicles in a Command and Control Denied Environment*, Monterey, Naval Postgraduate School, March 2015, https://apps.dtic.mil/sti/citations/ADA620661.

[8] Interview, 6 March 2023.

[9] Interview, 25 November 2022.

[10] Martino Travagnin, *Cold Atom Interferometry for Inertial Navigation Sensors. Technology Assessment: Space and Defence Applications*, Luxembourg, Publications Office of the European Union, 2020, p. 15, https://data.europa.eu/doi/10.2760/237221.

[11] Cal Biesecker, "Huntington Ingalls Scaling Open Architecture, Modularity to Its Larger UUVs", in *Defense Daily*, 11 January 2022, https://www.defensedaily.com/huntington-ingalls-scaling-open-architecture-modularity-to-its-larger-uuvs.

[12] Interview, 8 March 2023.

even the creation of underwater A2/AD bubbles.[13]

Nevertheless, it must be noted that UUVs still face the same challenges as crewed submarines, such as hampered communication and difficulties in detecting enemies and allies alike with passive sensors in the vastness of global oceans. For this reason, experts dismiss the possibility that UUVs employed as always-at-sea intelligence, surveillance and reconnaissance (ISR) assets could eventually turn oceans "transparent", a perspective that has sometimes been examined when discussing the future of sea-based nuclear deterrence. The prohibitive nature of the underwater domain, in terms of opacity, geology and distances, means it will be extremely difficult to dispel the stealthy nature of SSBNs, whose added value as a nuclear weapon delivery method resides precisely in their capacity to hide in a global environment impervious to easy detection.[14]

Yet, UUVs have a crucial advantage over any crewed system: persistence. The capacity to perform missions consistently and over long periods of time means that, even if persistence by itself does not help overcome issues associated with the underwater environment, UUVs can be force multipliers when it comes to submarine warfare. For instance, UUVs are well-suited to surveillance missions in proximity of chokepoints, such as ports or straits, where they can loiter for extended periods of time and where the physical constraints hampering operations in the open sea or very shallow and crowded waters are lessened. While they may not be capable of completely taking over ASW missions, UUVs may play a crucial supporting role to crewed systems. A notable exception in this regard is Russia, which is reportedly developing a "sub-killer" UUV designed to autonomously carry out ASW.[15] In any case, the perspective of UUVs carrying out attack missions against surface vessels, or even striking ground targets, is still far off.

Another set of missions revolves around intelligence tasks and surveillance of critical seabed infrastructures, which in turn are becoming ever more vulnerable to UUV sabotage. Again, technological innovation is opening up new deployment areas for underwater drones, as 66 per cent of global infrastructure such as seabed cables and gas pipelines is accessible to vehicles that can reach depths of 3,000m the percentage reaches 97 per cent if the vehicle can dive at depths of 6,000m.[16] In Europe, France has been the country that most recently decided to aim at the

[13] David Downie, "Automated Exclusion: Unmanned Concepts for Maritime Anti-Access and Area Denial", in *CFC Papers*, 2020, https://www.cfc.forces.gc.ca/259/290/22/305/Downie.pdf.

[14] Jonathan Gates, "Is the SSBN Deterrent Vulnerable to Autonomous Drones?", in *The RUSI Journal*, Vol. 161, No. 6 (2016), p. 28-35, DOI 10.1080/03071847.2016.1265834.

[15] Inder Singh Bisht, "Russian Navy Developing Unmanned Submarine Hunter", in *The Defense Post*, 20 January 2022, https://www.thedefensepost.com/2022/01/20/russian-navy-unmanned-submarine-hunter.

[16] "Europeans Wade into Fighting Seabed Threats with Drones and Sensors", in *Defense News*, 9 January 2023, https://www.defensenews.com/global/europe/2023/01/09/europeans-wade-into-fighting-seabed-threats-with-drones-and-sensors.

ISSN 2280-6164

© 2023 IAI

ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023

6,000m-target by launching the procurement of Kongsberg Hugin Superior AUVs.[17]

Finally, potentially very long endurance makes UUVs interesting candidates as carriers of nuclear second-strike capabilities. Russia is the global power that has been publicly pouring the most resources into this capability, developing the Status-6 Poseidon nuclear-powered and nuclear-armed UUV. While being referred by most foreign observers as a "torpedo", Russian sources use the terminology reserved for underwater drones (*bespilotnogo podvodnogo apparata*). Although little is known about the true specifications of the Poseidon, what has been officially publicised suggests a certain degree of autonomy given its virtually limitless range once launched from a submarine.[18] Because of this unique mix of capabilities, it has also been dubbed as a "fourth" component of the nuclear triad.[19] The first batch of Poseidons has reportedly already been produced, but the media prominence of this UUV makes it hard to disentangle facts from propaganda.[20]

2.3 Examples of UUV adoption and development

As mentioned, Russia is among the global powers that has invested the most in the development of UUVs. The Russian Ministry of commerce has reportedly invested up to 500 million roubles between 2020 and 2024 in a tender concerning the development of AUVs.[21] In parallel, Russian authorities have pushed for the launch of new hubs related to UUV technology. In 2022, President Putin himself has announced the opening of a production hub for "pilotless" vessels in Sevastopol,[22] while in the same year a centre for naval robotics has been inaugurated in Kronstad, on the Baltic Sea.[23]

Russia's interest in UUV technology is partly explained by Moscow's specific requirements when it comes to the Arctic. Here, the Russian Navy (*Voyenno-morskoy flot* – VMF) has decided to rely on a robust fleet of air and seaborne drones

---

[17] "DGA Selects Kongsberg's Hugin AUV for the French Navy", in *Naval News*, 21 October 2022, https://www.navalnews.com/?p=39046.

[18] H.I. Sutton, "Russia's New 'Poseidon' Super-Weapon: What You Need to Know", in Naval News, 3 March 2022, https://www.navalnews.com/?p=30954.

[19] Dmitry Kornev, "Deep Result: What Is Known about the Capabilities of the Underwater Poseidon", in *VPK News*, 1 May 2023, https://vpk.name/en/671649_deep-result-what-is-known-about-the-capabilities-of-the-underwater-poseidon.html.

[20] Joe Saballa, "Russia Produces First Poseidon Nuclear-Powered Torpedoes: Report", in *The Defense Post*, 18 January 2023, https://www.thedefensepost.com/2023/01/18/russia-poseidon-nuclear-torpedoes.

[21] "Russia Is Developing an Unmanned Maritime Technology", in *VPK News*, 20 November 2020, https://vpk.name/en/464434_russia-is-developing-an-unmanned-maritime-technology.html.

[22] "Развожаев предложил развернуть производство морских дронов в Севастополе" [Razvozhaev proposed to expand the production of marine drones in Sevastopol], in *RIA Novosti*, 2 November 2022, https://ria.ru/20221102/drony-1828773375.html.

[23] "The Center for Marine Robotics Has Started Work in Kronstadt", in *VPK News*, 21 February 2022, https://vpk.name/en/581346_the-center-for-marine-robotics-has-started-work-in-kronstadt.html.

to overcome the prohibitive waters of the high north.[24] UUVs such as the Klavesin 2[25] and the Shadow-2 have been expressly developed for arctic projection, similarly to the ambitious drone-based "Project Iceberg" for undersea energy exploitation.[26] An innovative addition to this family of vehicles, among others, is the Sarma UUV, which is being used to test the viability of an air independent unit.[27] This would allow the Sarma to cover thousands of kilometres despite lacking a nuclear power source and without the need to surface.[28]

Table 1 | Examples of UUV adoption and development

UUV	Producer	Length	Displacement	Max. depth	Mission
Remus 100[29]	Huntington Ingalls Industries	1.6m	<0t	100m	MCM, SAR, REA, ISR
Ghost Shark[30]	Anduril Australia	5.8m	2.8t	6,000m	ISR, potentially combat capabilities
Klavesin 2[31]	Rubin Design Bureau	7m	4t	6,000m	ISR, Arctic exploration
Hugin Superior AUV[32]	Kongsberg	6.4-6.6m	2.2t	6,000m	ISR, MCM, REA
Orca[33]	Boeing	25.9m	80t	>3,352m	MIW, ISR

[24] Elisabeth Gosselin-Malo, "Will the Ukraine War Slow Russia's Arctic Push?", in *Defense News*, 13 January 2023, https://www.defensenews.com/global/europe/2023/01/13/will-the-ukraine-war-slow-russias-arctic-push.

[25] Thomas Nilsen, "This Is Russia's New Unique Underwater Drone for Arctic Waters", in *The Barents Observer*, 12 July 2016, https://thebarentsobserver.com/ru/node/958.

[26] David Hambling, "Why Russia Is Sending Robotic Submarines to the Arctic", in *BBC News*, 21 November 2017, https://www.bbc.com/future/article/20171121-why-russia-is-sending-robotic-submarines-to-the-arctic.

[27] "Russia Develops Preliminary Design of AIP Unit for Sarma UUV", in *Naval News*, 21 September 2021, https://www.navalnews.com/?p=25903.

[28] H.I. Sutton, "Russian-Sarma-UUV", in *Covert Shores*, 28 February 2021, http://www.hisutton.com/Russian-Sarma-UUV.html.

[29] Unmanned Systems Technology (UST) website: *Remus 100 UUV*, https://www.unmannedsystemstechnology.com/company/hii-unmanned-systems/remus-100-uuv.

[30] Julian Kerr, "Australia's Future Extra-Large UUV Named 'Ghost Shark'", in *Janes*, 12 December 2022, https://www.janes.com/defence-news/news-detail/australias-future-extra-large-uuv-named-ghost-shark.

[31] "Russia Started Sea Trials of Klavesin-2 UUV in Crimea", in *Navy Recognition*, May 2008, http://www.navyrecognition.com/index.php/focus-ysis/naval-technology/6234.

[32] Kongsberg website: AUV-Hugin Superior, https://www.kongsberg.com/maritime/products/marine-robotics/autonomous-underwater-vehicles/AUV-hugin-superior; Christian Cione, "AUV Hugin Superior scelto per la Marina militare francese", in *CUENews Marine*, 21 October 2022, https://marinecue.it/?p=31828.

[33] Dan Parsons, "Navy's 85-Foot Orca Unmanned Submarine Will Be a Minelayer First", in *The Drive*,

DOCUMENTI IAI 23 | 13 - JUNE 2023
ISSN 2280-6164

More broadly, the last five years have seen worldwide interest in experimenting the development of larger UUVs, in particular for countries with an oceanic perspective such as the US, the UK, China, France, and Australia.[34]

The US, for instance, is currently testing the deployment of the Snakehead large displacement UUV,[35] expected to be a modular multi-mission vehicle designed to deliver ISR support to underwater missions, as well as mine warfare tasks. The first exemplary has been christened in 2022, and in the future the Snakehead is also expected to be able to equip lethal payloads.[36] The US Navy has also announced a modernisation of its ISR and mine countermeasures (MCM) capabilities via its Lionfish programme, which has finally settled on Huntington Ingalls Industries' Remus 300.[37] At the same time, the Navy is also exploring the possibility of assigning the task of scattering anti-submarine mines to UUVs. Here, the first prototypes are expected for the end of 2023.[38]

China's People's Liberation Army Navy (PLAN) has also pursued the development of LUUVs, in an attempt to fill its traditional capabilities gaps in submarine warfare. The HSU001 was first presented in 2019, of which few characteristics are known.[39] Around the same time, the Xiangyanghong 06 survey ship released 12 undersea gliders[40] – unpowered sensors carried by the currents which can play an important role for ISR purposes, especially when deployed along critical sea lines of communication (SLOCs).[41] Satellite imagery and pictures taken at a naval expo in 2023 also indicate that Beijing has started the development of XLUUVs derived from the HSU001,[42] although no official information exists on the matter.[43] Moreover,

27 May 2022, https://www.thedrive.com/the-war-zone/navys-85-foot-orca-unmanned-submarine-will-be-a-minelayer-first.

[34] Interview, 6 March 2023.

[35] "US Navy Tests Snakehead LDUUV For Autonomous Missions", in *Naval News*, 12 August 2022, https://www.navalnews.com/?p=36461.

[36] H.I. Sutton, "Snakehead: The U.S. Navy's Large Submarine-Deployable Underwater Drone", in *Covert Shores*, 17 May 2022, http://www.hisutton.com/Snakehead-LDUUV.html.

[37] Justin Katz, "Navy Moving Ahead with HII for Small UUV Program", in *Breaking Defense*, 21 March 2022, https://breakingdefense.com/?p=211233.

[38] Paul McLeary, "PRC, Russian Subs May Soon Face UUV-Launched US Sea Mines", in *Breaking Defense*, 13 April 2020, https://breakingdefense.com/?p=101432.

[39] Lyle J. Goldstein, "China's Underwater Unmanned Vehicles: How They'll Dominate Undersea Combat", in *The Reboot*, 29 January 2022, https://nationalinterest.org/node/200098.

[40] H.I. Sutton, "China Deployed 12 Underwater Drones in Indian Ocean", in *Forbes*, 22 March 2020, https://www.forbes.com/sites/hisutton/2020/03/22/china-deployed-underwater-drones-in-indian-ocean.

[41] H.I. Sutton, "Underwater Drone Incidents Point to China's Expanding Intelligence Gathering", in *RUSI Commentaries*, 15 January 2021, https://rusi.org/explore-our-research/publications/commentary/underwater-drone-incidents-point-chinas-expanding-intelligence-gathering.

[42] H.I. Sutton, "China Reveals New Heavily Armed Extra-Large Uncrewed Submarine", in *Naval News*, 23 February 2023, https://www.navalnews.com/?p=42551.

[43] H.I. Sutton, "China's New Extra-Large Submarine Drones Revealed", in *Naval News*, 16 September 2022, https://www.navalnews.com/?p=37541.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

UUVs could be especially suited for the PLAN's approach to maritime grey zone operations in its vast EEZ, thanks to the difficulty of tracing a UUV's origin.[44]

The ever-increasing emphasis on UUVs is due to a growing demand for multipurpose vehicles capable of performing multiple missions, carrying diverse payloads and sporting high rates of endurance.[45] This mix of features necessarily implies larger displacements and more complex vehicles, and is reflected by the most recent requirements put out by navies worldwide: the Royal Australian Navy's (RAN) XLUUV Ghost Shark, for instance, should navigate for up to 10 days at depths of up to 6,000m.[46] For Australia, the deployment of UUVs may be especially advantageous to survey the numerous chokepoints to its north, conduct mine-laying operations and generally granting more flexibility to the RAN, requiring enough power to allow the XLUUV to loiter for extended periods of time.[47] Finally, a notable addition to the fold of XLUUVs will be ThyssenKrupp's Modifiable Underwater Mothership, designed to deploy smaller RUVs and transport cargos.[48]

Finally, Western countries have established specialised UUV development clusters and experimental units. NATO's Maritime Unmanned Systems (MUS) initiative has an important underwater component dedicated to standardisation and interoperability. The Alliance's Science and Technology Organization (STO) runs a Centre for Maritime Research and Experimentation (CMRE) in La Spezia, whose research also includes Autonomous Undersea Surveillance and Intervention.[49] Operational experimentations through NATO's yearly Robotic Experimentation and Prototyping with Maritime Unmanned Systems (REPMUS) Exercise is seen as a valuable occasion to identify viable technologies and research trajectories.[50] NATO also plays a major role by forging common standards, which are expected to be a far more complicated endeavour compared to other domains due to the difficulties of data transmission in a non-permissive physical environment.[51] Work is currently being carried out on the definition of an all-domain NATO Standardisation Agreement (STANAG) for uncrewed vehicles, which unlike current STANAG 4586

[44] Prakash Panneerselvam, "Unmanned Systems in China's Maritime 'Gray Zone Operations'", in *The Diplomat*, 23 January 2023, https://thediplomat.com/2023/01/unmanned-systems-in-chinas-maritime-gray-zone-operations.

[45] Interview, 8 March 2023.

[46] Julian Kerr, "Australia's Future Extra-Large UUV Named 'Ghost Shark'", cit.

[47] Franz-Stefan Gady, "Australia's Future Submarine Fleet and Uninhabited Undersea Systems", in *IISS Online Analyses*, 23 September 2021, https://www.iiss.org/online-analysis/online-analysis/2021/09/australias-future-submarine-fleet-and-uninhabited-undersea-systems.

[48] H.I. Sutton, "World's Largest Submarine Drone Being Built in Germany", in *Naval News*, 8 February 2023, https://www.navalnews.com/?p=42083.

[49] NATO Centre for Maritime Research and Experimentation (CMRE) website: *Autonomous Undersea Surveillance and Intervention*, https://www.cmre.nato.int/research/mine-countermeasures.

[50] Alessandro Marrone and Michele Nones, "Conclusions", in Alessandro Marrone and Elio Calcagno (eds), "Naval Combat Systems: Developments and Challenges", in *Documenti IAI*, No. 23|01 (January 2023), p. 87-88, https://www.iai.it/en/node/16476.

[51] Interview, 8 March 2023.

ISSN 2280-6164

should apply beyond UAVs.[52]

Purely national examples also abound. In Italy, the National Underwater Hub in La Spezia on the other end serves as an incubator for public-private cooperation.[53] The US and the UK have launched Unmanned Undersea Vehicles Squadron ONE (UUVRON, 2017) and NavyX (2019) respectively, which act as accelerators for experimental technology. UUVRON, in particular, has evolved from a demonstrator unit under Submarine Development Squadron 5[54] to a fully-fledged submarine major force command.[55]

[52] Interview, 25 October 2022.

[53] See chapter 7 in this study.

[54] "Navy Establishes First UUV Squadron, UUVRON 1", in *AUVSI News*, 29 September 2017, https://www.auvsi.org/node/456543.

[55] Amelia Umayam, "UUVRON-1 Becomes Major Command and Conducts Change of Command Ceremony", in *DVIDS News*, 18 July 2022, https://www.dvidshub.net/news/425249/uuvron-1-becomes-major-command-and-conducts-change-command-ceremony.

ISSN 2280-6164

3. An overview of the European context

by Michelangelo Freyrie

3.1 United Kingdom

The underwater domain plays a central role in the maritime security outlook of the United Kingdom. The development of instruments for submarine and anti-submarine warfare have always been front and centre in British defence thinking, also thanks to the Royal Navy’s (RN) unique role as guardian of the UK’s nuclear deterrent.

The 2020s have nevertheless seen a spike in interest in the underwater sector, given the juncture of current procurement cycles and the shifts in the strategic environment. The 2022 Maritime Security Strategy, published just one month before the Nord Stream sabotage, highlights the necessity of defending critical seabed infrastructures such as gas pipelines and cables.[1] The threat to SLOCs and underwater infrastructures stemming from Russia’s new *Yasen-M*-class submarines and special-purpose subsurface vehicles is perceived as particularly urgent in London.[2] Moreover, an ongoing review of the RN’s fleet balance suggests that submarines may play an ever-growing role in Britain’s force structure. The unique capacity of these types of ships to penetrate enemy A2/AD bubbles and their immunity to new weapon systems, such as hypersonic missiles, are pointed to as important features.[3]

The United Kingdom is currently carrying out a comprehensive update of its submarine fleet. The RN has currently planned the launch of two additional *Astute*-class nuclear-powered hunter killer submarines to complete the phasing out and substitution of the old *Trafalgar*-class SSNs.[4] At the same time, the current priority consists in the full modernisation of the British SSBN fleet and subsequently of the UK’s sea-based nuclear deterrent through the construction of four *Dreadnought*-class ships, which should be completed by the early 2030s.[5]

[1] UK Government, *National Strategy for Maritime Security*, 15 August 2022, https://www.gov.uk/government/publications/national-maritime-security-strategy.

[2] Sidharth Kaushal, “United Kingdom”, in Alessandro Marrone and Elio Calcagno (eds), “Naval Combat Systems: Developments and Challenges”, in *Documenti IAI*, No. 23|01 (January 2023), p. 66, https://www.iai.it/en/node/16476.

[3] Dominic Nicholls and Danielle Sheridan, “Ben Wallace: Submarines Rather than Ships Could Be the Royal Navy’s Future”, in *The Telegraph*, 2 September 2022, https://www.telegraph.co.uk/politics/2022/09/02/ben-wallace-submarines-rather-ships-could-royal-navys-future.

[4] “SSN Astute-Class Nuclear Submarines, UK”, in *Naval Technology*, 16 February 2023, https://www.naval-technology.com/?p=4644.

[5] “Dreadnought-Class Nuclear-Powered Ballistic Missile Submarines”, in *Naval Technology*, 15 February 2023, https://www.naval-technology.com/?p=50841.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

While the modernisation drive is in full swing, a reflection has already started on the successors of the existing generation of submarines. Discussions have been particularly prominent when it comes to the Submersible Ship Nuclear (Replacement) programme, also dubbed SSN(R), while less is known about the successor of the current generation of SSBNs. Talks about SSN(R) inevitably converge with the British participation in AUKUS, the tri-national alliance with Australia and the United States on the development of a common design for nuclear-powered submarines. SSN(R) has been used as a starting point for the development of a joint British-Australian class, known as an SSN-AUKUS, that will also incorporate US components.[6] The British design is considered an ideal starting point also due to the projected increase in tonnage originally projected for SSN(R) (11,000t versus the 7,400t of the *Astute* class).[7]

The overall size of the Royal Navy's submarine fleet is still a matter of debate. The Parliament's defence committee has voiced doubts[8] about the ability of the RN to fully perform its missions with the currently projected size.[9] Indeed, particular pressure is expected on the SSN fleet, which in the next few years is also likely to play a growing role in the Southern Hemisphere.[10] This is particularly true in the Indo-Pacific,[11] where British SSNs are expected to regularly be deployed as part of the AUKUS agreement.[12]

The Royal Navy has also invested in new underwater surveillance capabilities and has decided to acquire a second Multi-Role Ocean Surveillance Ship (MROS),[13] up from one recently purchased and integrated in the Royal Navy's Auxiliary.[14] The

[6] UK Government, *British-led Design Chosen for AUKUS Submarine Project*, 13 March 2023, https://www.gov.uk/government/news/british-led-design-chosen-for-aukus-submarine-project.

[7] Nick Childs, "AUKUS and the Nuclear Reaction", in *Military Balance Blog*, 27 January 2023, https://www.iiss.org/online-analysis/military-balance/2023/01/aukus-and-the-nuclear-reaction.

[8] UK House of Commons Defence Committe, *"We're Going to Need a Bigger Navy": Government Response to the Committee's Third Report*. Fifth Special Report of Session 2021–22, 25 February 2022, https://publications.parliament.uk/pa/cm5802/cmselect/cmdfence/1160/report.html.

[9] Speculations even include prospect an extreme growth of the British SSN flotilla, "taking the potential size of the fleet to 19". See: Aubrey Allegretti, "Size of UK's Nuclear Submarine Fleet Could Double under Aukus Plans", in *The Guardian*, 13 March 2023, https://www.theguardian.com/p/ngmye.

[10] Australia is expected to suffer a capability gap due to the age of its Collins-class ships has even led to speculation the United Kingdom may restart the production of cheaper conventionally powered submarines as a stopgap solution on the road towards a bigger SSN fleet. See: Nick Childs, "Naval Balance: Some Deep-Dive UK Thinking", in *Military Balance Blog*, 16 September 2022, https://www.iiss.org/online-analysis/military-balance/2022/09/naval-balance-some-deep-dive-uk-thinking.

[11] Latika Bourke, "British Subs Could Patrol Indo-Pacific While Australia Procures Its Own Fleet", in *The Sydney Morning Herald*, 1 September 2022, https://www.smh.com.au/world/europe/british-subs-could-patrol-indo-pacific-while-australia-procures-its-own-fleet-20220901-p5befb.html.

[12] White House, *Joint Leaders Statement on AUKUS*, 13 March 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/03/13/joint-leaders-statement-on-aukus-2.

[13] Andrew Chuter, "UK Military Ups Investments in Undersea Surveillance", in *Defense News*, 16 November 2022, https://www.defensenews.com/global/europe/2022/11/16/uk-military-ups-investments-in-undersea-surveillance.

[14] UK Royal Navy, *Navy's New Guardian of Key Underwater Infrastructure Arrives in UK*, 19 January

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

ship is capable of launching UUVs for the protection of underwater infrastructures. In the words of Secretary of State for Defence Wallace, the addition of two MROS was deemed necessary to bolster "[British] capabilities and security against threats posed now and into the future", referring to the risks born out of potential Russian sabotage to underwater infrastructure.[15] The United Kingdom was among the littoral states which joined the joined patrol efforts after the Nord Stream incident, dispatching a Type-23 ASW frigate and the survey ship HMS Enterprise.[16]

Additionally, the RN has announced a programme, dubbed "Project Cetus", to develop a XLUUV to be teamed with Astute-class SSNs.[17] Project Cetus aims at exploiting the lessons from a technological demonstrator developed by the Ministry of Defence's (MoD) Defence and Security Accelerator. It is funded through the RN's Project Spearhead Anti-Submarine Warfare programme (launched in 2019) and is expected to also contribute to the design of SSN(R).[18] This follows the British conception of underwater MUM-T, which sees UUVs primarily as carriers of sensors within a network in which SSNs are cast as primary nodes. The Royal Navy currently deploys Remus 100 and 600 UUVs for MCM operations.[19]

3.2 France

Like the United Kingdom, France is not shy about its capabilities in the underwater domain, which is considered crucial for its power projection both in the conventional and nuclear arenas. The *Marine Nationale* (MN) currently fields twelve nuclear-powered submarines,[20] composing the *Forces sous-marines* (Underwater forces – FSM). The FSM is split in two distinct squadrons, tasked with two complementary missions and purpose-built units. The *Escadrille des Sous-marines nucléaires d'attaque* (Nuclear Attack Submarines Squadron – ESNA) holds all eight of the country's SSNs, while the country's SSBNs are under the purview of the *Escadrille des Sous-marines lanceurs d'engins* (Missile Submarines Squadron – ESNLE).[21] Both types of vessels are currently undergoing a modernisation drive,

2023, https://www.royalnavy.mod.uk/news-and-latest-activity/news/2023/january/19/20230119-navys-new-guardian-of-key-underwater-infrastructure-arrives-in-uk.

[15] George Allison, "Britain's New Undersea Cable Protection Ship Arrives", in *UK Defence Journal*, 19 January 2023, https://ukdefencejournal.org.uk/?p=43103.

[16] Jonathan Bentham and Nick Childs, "Seabed Security after Nord Stream: In Search of a Clear Vision", in *Military Balance Blog*, 14 October 2022, https://www.iiss.org/online-analysis/military-balance/2022/10/seabed-security-after-nord-stream-in-search-of-a-clear-vision.

[17] Andrew Chuter, "UK Navy to Take Drone-Teaming Operations Underwater with New Submarine", in *Defense News*, 1 December 2022, https://www.defensenews.com/global/europe/2022/12/01/uk-navy-to-take-drone-teaming-operations-underwater-with-new-submarine.

[18] "Royal Navy Purchases Its First Uncrewed Submarine", in *Navy Lookout*, 1 December 2022, https://www.navylookout.com/royal-navy-purcases-its-first-uncrewed-submarine.

[19] "Royal Navy Grows Remus 100 Fleet with Latest Arrivals", in *Shephard Media*, 21 September 2022, https://www.shephardmedia.com/news/naval-warfare/royal-navy-grows-remus-100-fleet-with-latest-arrivals.

[20] "France Submarine Capabilities", in *NTI Fact Sheets*, 28 February 2023, https://www.nti.org/?p=21182.

[21] "Les sous-marins français", in *Defense Zone*, 27 April 2021, https://defense-zone.com/blogs/

with follow-on classes planned for the 2030s.

ESNA should see all of its units substituted with the new *Barracuda*-class SSNs in 2030, providing some new capabilities to the *Marine Nationale*. The *Barracuda*-class is the first French SSN departing from a purely underwater hunting and escort function. It is equipped with conventional cruise missiles and is capable of carrying out deep-strike land attacks.[22] It also requires just a single technical stop for maintenance per year, greatly enhancing the system's endurance. Following a similar multirole-oriented paradigm, the four *Le Triomphante*-class SSBNs are also equipped with SM39 Exocet anti-ship missile, alongside contributing to France's nuclear deterrent. From 2023 onwards, the French industrial base will also be focused on the development of the country's third generation SSBN vessel (dubbed SNLE 3G). The work will be concentrated at Naval Groups' Cherbourg submarine shipyard and will involve most of the country's naval companies.[23]

The debates about the return of high-intensity warfare as a combat scenario has opened some new questions about the size of the FSM and the prioritisation of SSNs over SSBNs. The retirement of the *Marine Nationale*'s SSKs in 2001 has led some to call for the conversion of older SSBNs models into SSNs.[24] The current chief of staff of the MN has however stated that it would not be in the interest of the Navy to do so, both because of the early obsolescence of such converted SSBNs and the difficulties in manning an expanded submarine force.[25]

In 2022, France's minister of Armed forces presented the nation's first seabed strategy (*Stratégie ministérielle de maitrise des fonds marins*), introducing some innovation to how the MN (and the defence institutions more broadly) looks at the underwater domain.[26] The document identifies the need of creating a doctrinal corpus specifically dedicated to the application of multi-domain concepts to the underwater and seabed environments. With this perspective, the strategy pushes for the conceptualisation of so-called *Opérations de maîtrise des fonds marins* (Seabed mastery operations).[27] The strategy sets the objective to acquire UUVs –

news/lsous-marins-francais.

[22] Nathan Gain, "France's New Submarine Suffren Completes First Operational Deployment", in *Naval News*, 6 January 2023, https://www.navalnews.com/?p=41285.

[23] Xavier Vavasseur, "France Launches Third Generation SSBN Program – SNLE 3G", in *Naval News*, 21 February 2021, https://www.navalnews.com/?p=20045.

[24] Laurent Lagneau, "Avec le retour de la « haute intensité", la Marine nationale aura-t-elle assez de sous-marins ?", in *Zone Militaire*, 12 September 2021, https://www.opex360.com/2021/09/12/avec-le-retour-de-la-haute-intensite-la-marine-nationale-aura-t-elle-assez-de-sous-marins.

[25] Laurent Lagneau, "L'amiral Vandier tord le cou à l'idée de convertir des SNLE en sous-marins lanceurs de missiles de croisière", in *Zone Militaire*, 12 February 2023, https://www.opex360.com/2023/02/12/lamiral-vandier-tord-le-cou-a-lidee-de-convertir-des-snle-en-sous-marins-lanceurs-de-missiles-de-croisiere.

[26] French Ministry of Defence, *Stratégie ministérielle de maitrise des fonds marins*, February 2022, https://www.defense.gouv.fr/actualites/armees-se-dotent-dune-strategie-ministerielle-maitrise-fonds-marins.

[27] Ibid, p. 9.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI

ISSN 2280-6164

both AUVs and ROUVs – capable of reaching depths of up to 6,000 metres. This target is dictated by the fact that 10 per cent of global undersea cables is directed to or passes through French sovereign areas, making it an important piece of infrastructure to be put under surveillance. France currently has the world's largest EEZ due to its numerous overseas territories;[28] as such, reconnaissance and mapping of interdicted waters are mentioned by the document as crucial preparatory work to be carried out by UUVs preceding submarine and deterrence operations. The procurement of ISR-capable UUVs to complement the existing *Ulisse* and *Diomede*[29] is set to begin in 2025. At the same time, new priorities set by Paris also include the so-called Capacité Hydrographique et Océanographique Future (Future Hydrographic and Oceanographic Capability – CHOF) to enhance the MN's seabed mapping capacities, as well as the uncrewed anti-mines units SLAM-F.[30]

3.3 Sweden

Sweden is among the few Western countries with recent experience in large-scale ASW operations, although not in an active conflict. While not (yet) a NATO ally, already in 2014, the Swedish navy (*Svenska Marinen* – SM) was forced to perform a multidomain anti-submersible operation in the Baltic, likely to counter the intelligence efforts of Russian submarines.[31] With Russia's aggressive posture in Europe and the sabotage of the Nord Stream 1 and 2 pipelines a few miles from its shores, Sweden's regional security environment is likely to deteriorate further over the next years. At the same time, Stockholm's upcoming accession to NATO is going to change the country's defence policy and military commitments.[32] The transformation of the Baltic Sea into a kind of "NATO lake" will not necessarily decrease the intensity of Russian underwater operations in the region. The first *Ubåtsflottiljen* (submarine flotilla) currently fields the nation's five diesel-electric attack submarines,[33] all equipped with an AIP system which is the pride of Sweden's defence industrial base.[34]

[28] "Drops in the Ocean: France's Marine Territories", in *The Economist*, 13 January 2016, https://www.economist.com/graphic-detail/2016/01/13/drops-in-the-ocean-frances-marine-territories.

[29] Charlotte Le Breton and Hugo Decis, "France's Deep Dive into Seabed Warfare", in *Military Balance Blog*, 25 February 2022, https://www.iiss.org/online-analysis/military-balance/2022/02/frances-deep-dive-into-seabed-warfare.

[30] Nathan Gain, "French Navy Tests SLAM-F Mine Warfare Unmanned System off Brest", in *Naval News*, 26 October 2022, https://www.navalnews.com/?p=38705. See also: Thales, T*he Maritime Mine Countermeasures Programme: The French and British Navies Blaze the Trail Towards a Global First with Their Revolutionary Autonomous Systems*, 13 September 2019, https://www.thalesgroup.com/en/node/2728642.

[31] Magnus Nordenman, "Lessons from Sweden's Sub Hunt", in *USNI News*, 28 October 2014, https://news.usni.org/?p=9704.

[32] Karolina Muti, "Svezia e Finlandia nella Nato: scacco sul Baltico, ma non è tutto oro quel che luccica", in *AffarInternazionali*, 1 June 2022, https://www.affarinternazionali.it/?p=98416.

[33] "Sweden Submarine Capabilities", in *NTI Fact Sheets*, 2 March 2023, https://www.nti.org/?p=21294.

[34] For a discussion on AIP capabilities and their merits, see chapter 1 of this study.

Despite being at the forefront of SSK technology, Sweden's modernisation efforts have been met with some difficulties over the last decades. While the newest submarine in service, the *Södermanland*-class HSwMS Östergötland, has been commissioned in 1994, the development of a new generation of submarines has experienced some hurdles. Plans for A24 *Viking*-class SSKs, to be developed with other Scandinavian countries, were scuttled in 2004,[35] while the launch of the first-of-its-class A26 *Blekinge* has been delayed.[36] At the same time, Stockholm's shipbuilding industry has undergone some turbulence, with the sale of the country's main submarine builder Kockums to ThyssenKrupp in 1999 and its successive purchase by Saab in 2013. Crucially, the repatriation of Kockums has been facilitated by the Swedish government's investment in the underwater domain, including the order of ROUVs and the overhaul of *Gotland*-class vessels.[37]

In this context, Sweden is trying to invest in the development of a next-generation submarine capability, while providing stopgap solutions for the next decade. The *Södermanland* class will be modernised thanks to an investment of 470 million Swedish krona (41 million euro),[38] while the *Svenska Marinen* already operates Saab's SubROV tethered drone. The unit is designed to perform ISR and recovery missions and can be launched from regular torpedo tubes.[39] Meanwhile, the bows of the upcoming *Blekinge* class should include a Multi-Mission Portal to allow flexible payloads, ranging from special operation forces (SOF) modules to advanced UUVs.[40] The A26 will be specialised in littoral operations, but larger versions for blue water navies are expected for the export markets.[41] At the same time, Sweden is also pursuing other modernisation efforts – most notably, the substitution of the ROUVs mothership HSwMS Belos[42] and the extension of the Navy's *Koster*-class mine countermeasures ships.[43] The Belos was also involved in Sweden's response to the Nord Stream incidents,[44] which continues to captivate the attention of the

[35] GlobalSecurity.org: *A24 Viking*, https://www.globalsecurity.org/military/world/europe/a24-viking.htm.

[36] "Swedish Submarines of the A26 Project Turned into a Long-term Construction", in *VPK News*, 1 September 2021, https://vpk.name/en/537768_swedish-submarines-of-the-a26-project-turned-into-a-long-term-construction.html.

[37] Martin Lundmark, "Saab Kockums' Maiden Voyage (Part.2)", in *Défense&Industries*, No. 2 (October 2014), p. 11, https://www.frstrategie.org/en/node/1981.

[38] Joe Saballa, "Saab to Upgrade Swedish Submarine for $44 Million", in *The Defense Post*, 16 September 2022, https://www.thedefensepost.com/2022/09/16/saab-upgrade-sweden-submarine.

[39] Xavier Vavasseur, "Swedish Navy Submarines Now Fitted with SubROV Submarine Remotely Operated Vehicle", in *Naval News*, 4 March 2019, https://www.navalnews.com/?p=2962.

[40] Yannick Smaldore, "Saab's A26 Submarine Program Transitioning from Design to Production", in *Naval News*, 8 October 2020, https://www.navalnews.com/?p=16564.

[41] David Szondy, "Sweden's New Submarine Could Shift Balance of Power in the Baltic Sea", in *New Atlas*, 1 August 2022, https://newatlas.com/military/swedish-blekinge-class-submarine-baltic-sea-balance-of-power.

[42] Robin Häggblom, "Changes Ahead for Swedish Naval Plans", in *Naval News*, 3 November 2022, https://www.navalnews.com/?p=39373.

[43] Fatima Bahtić, "Saab Gets to Work on Two Swedish Koster-Class Mine Countermeasures Ships", in *Naval Today*, 21 December 2022, https://www.navaltoday.com/?p=62746.

[44] Jonathan Bentham and Nick Childs, "Seabed Security after Nord Stream", cit.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

country's armed forces.[45]

3.4 Spain

Spain is the latest European country to have developed an indigenous submarine system for its navy. With the upcoming deployment of the S-80+ *Isaac Peral*-class submarines, the Spanish Navy (*Armada*) will start substituting its three *Agosta*-class SSKs and eventually return to a four-vessels flotilla.[46] Despite Spain's significant shipbuilding capabilities, most notably through Navantia, the *Agosta* has been produced using a French design and in collaboration with Naval Group.[47]

The S-80+ class will be the first foray into a completely national class for Spain in decades, but its development has proven particularly difficult due to budgetary problems, engineering mistakes and a mismatch between the vessel's specifications and infrastructure at the fleet's Cartagena base.[48] The programme has also experienced significant cost increases, with the price tag ballooning from 1.75 billion euro under the 2004 contract to 2.21 billion euro in 2010 for four submarines.[49] Nevertheless, the first-in-class *Isaac Peral* has been finally launched in 2021, has underwent the first sea trials in 2022 and is expected to be handed over to the *Armada* in 2023. The other three vessels are projected to be built between 2024 and 2027.[50] Despite the issues that have plagued the programme, the *Isaac Peral* compares favourably to its *Scorpène*-class counterparts. It is larger, allowing for an extra deck level, and has been designed from the beginning as an AIP submarine.[51] Moreover, unlike other AIP units, the S-80+ class will utilise what Navantia calls "Bio-Ethanol Stealth Technology", solving some issues regarding hydrogen storage typical of classic AIP systems. The *Isaac Peral* also retains the capability of launching Tomahawk land-attack cruise missiles, although Spain has reportedly still not decided on a purchase of such weapons.[52] The S-80+ can also carry the DM2A4 heavy torpedo SeaHake and can be armed with the UGM-84 anti-

[45] Swedish Armed Forces, *The Swedish Navy Is Vigilant Year-Round and Around the Clock*, 3 October 2022, https://www.forsvarsmakten.se/en/news/2022/10/the-swedish-navy-is-vigilant-year-round-and-around-the-clock.

[46] Spanish Navy website: *Submarine Fleet Force*, https://armada.defensa.gob.es/ArmadaPortal/page/Portal/ArmadaEspannola/conocenosorganizacion/prefLang-en/03Flota--06FLOSUB.

[47] Navantia website: *Submarines. Experience and Capabilities*, https://www.navantia.es/en/business-areas/submarines/experience-capabilities.

[48] Blake Stilwell, "How a Misplaced Decimal Point Nearly Took Down Spain's Newest Submarines", in *Military.com*, 29 April 2021, https://www.military.com/node/345306.

[49] "Navantia a Step Closer to Fixing Spanish Submarine's Weight Problem", in *Naval Today*, 6 April 2016, https://www.navaltoday.com/?p=40229.

[50] Kate Tringham, "First Spanish S-80 Plus Submarine Starts Sea Trials", in *Janes*, 31 May 2022, https://www.janes.com/defence-news/news-detail/first-spanish-s-80-plus-submarine-starts-sea-trials.

[51] H.I. Sutton, "The First S-80-Plus Class Submarine Will Launch New Era for Spanish Navy", in *Naval News*, 22 April 2021, https://www.navalnews.com/?p=21326.

[52] H.I. Sutton, "Spain's S-80P Isaac Peral Class AIP Submarine", in *Covert Shores*, 28 March 2022, http://www.hisutton.com/S-80-Isaac-Peral-Class-Submarine.html.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

ship missile Sub-Harpoon, as well as mines by SAES.[53]

Although the press reported ongoing studies to integrate the S-80+ with UUVs,[54] it is unclear whether such research has progressed.[55] It is worth noting that Spain's procurement of UUVs has been subject to multiple delays due to the Covid-19 pandemic.[56] The Barracuda programme, launched in 2019, is meant to substitute the Armada's ROUVs with AUVs for MCM purposes, while plans also exist pertaining the purchase of two AUVs for MCM and hydrographic operations.[57] The development of UUVs has been included in the 2020 Defence Technology and Innovation Strategy.[58] Other relevant underwater investments include the procurement of the TUUM-6 underwater communication system ("underwater telephone"), one of the components of Thales integrated suite of sonars and acoustic systems,[59] which will be equipped on the *Armada*'s new multi-mission frigates,[60] and the acquisition of Saab's Leopard ROUV in 2021.[61]

3.5 European and transatlantic cooperation

The European Union has recognised the economic and military importance of the underwater domain, as well as the vulnerability of UCIs. In the most recent update of the EU Maritime Security Strategy, the EU Commission addresses the impact of current technological advancements, stating that "it is imperative to provide continued support to Member States to develop underwater protective assets and counter-drone solutions".[62] The same document also highlights the need for

[53] "Spanish Navy's First S-80 Plus-Class Submarine to Begin Mooring Trials", in *Naval Technology*, 18 January 2022, https://www.naval-technology.com/?p=67818.

[54] Giulia Tilenni, "S80 Submarine Update", in *European Security & Defence*, 29 October 2020, https://euro-sd.com/2020/10/headline/19628/navantia-s80-update-at-euronaval.

[55] Notably, UUVs integration is absent from current technical cards. See Navantia: *S-80* (Factsheet), April 2021, https://www.navantia.es/wp-content/uploads/2021/04/S-80_Ficha-ingles.pdf.

[56] José María Navarro García, "Vehículos navales no tripulados para la Armada española", in *Defensa.com*, 4 January 2023, https://www.defensa.com/defensa-naval/vehiculos-navales-no-tripulados-para-armada-espanola.

[57] José María Navarro García, "La Armada española adquirirá dos vehículos submarinos autónomos", in *Defensa.com*, 19 January 2023, https://www.defensa.com/defensa-naval/armada-adquirira-dos-vehiculos-submarinos-autonomos.

[58] Spanish Ministry of Defence, *Defence Technology and Innovation Strategy ETID – 2020*, Madrid, December 2020, https://publicaciones.defensa.gob.es/defence-technology-and-innovation-strategy-etid-2020-libros-pdf.html.

[59] Joe Saballa, "Thales Developing Underwater Communication System for Spanish Navy", in *The Defense Post*, 18 June 2021, https://www.thedefensepost.com/2021/06/18/spain-navy-underwater-communication-system.

[60] Thales, *Thales Integrated Sonar Suite Selected for Spanish Navy's New Multi-Mission Frigates*, 12 December 2019, https://www.thalesgroup.com/en/group/press-release/thales-integrated-sonar-suite-selected-spanish-navys-new-multi-mission-frigates.

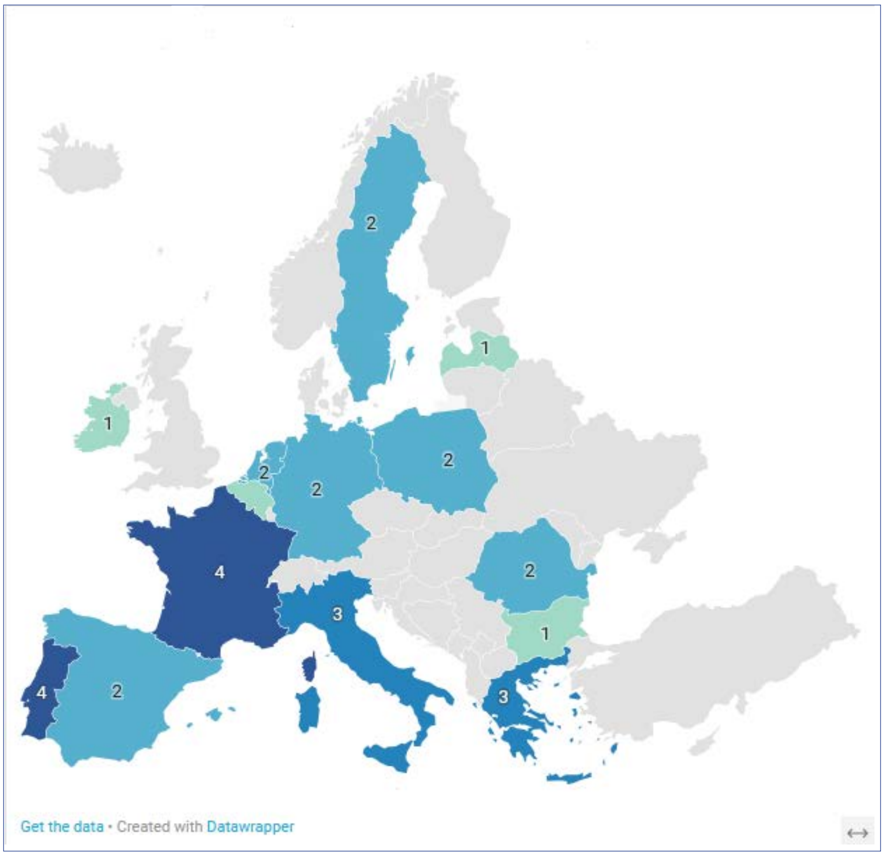
[61] "Spanish Navy Acquires Leopard ROVS through NSPA", in *Naval News*, 23 April 2021, https://www.navalnews.com/?p=21382.

[62] European Commission, *Update of the EU Maritime Security Strategy and Its Action Plan* (JOIN/2023/8), 10 March 2023, p. 11, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52023JC0008.

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

cooperative programmes in the realm of underwater situational awareness and to encourage the pursuit of relevant defence R&D.

Figure 1 | Participation in underwater-related PESCO projects



This commitment is reflected by numerous R&D initiatives within the frameworks of the Permanent Structured Cooperation (PESCO) and the European Defence Fund (EDF). The former counts six projects in the underwater domain:[63] Maritime Unmanned Anti-Submarine System (MUSAS), Harbour and Maritime Surveillance and Protection (HARMSPRO), Deployable Modular Underwater Intervention Capability (DIVEPACK), Maritime (Semi-) Autonomous Systems for Mine Countermeasures (MAS MCM), Critical Seabed Infrastructure Protection (CSIP) and Anti-Torpedo Torpedo (ATT), of which the latter two have been added with the most recent round of PESCO projects.[64]

The EU has also provided direct financing to numerous underwater-related initiatives. OCEAN 2020, funded through the 2017 Preparatory Action on Defence

[63] PESCO website: *Projects*, https://www.pesco.europa.eu/projects.

[64] European Defence Agency, *11 New PESCO Projects Focus on Critical Defence Capabilities and Interoperability*, 23 May 2023, https://eda.europa.eu/news-and-events/news/2023/05/23/11-new-pesco-projects-to-focus-on-critical-defence-capabilities-and-interoperability.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

Research (PADR) provided some experimentation regarding underwater payloads.[65] However, the majority of current projects are being financed with 2022 and 2023 EDF calls. EDF 2022 contains a call on underwater MUM-T and swarming (EDF-2022-RA-UWW-UTS) and observation, detection, acquisition and communications (EDF-2022-RA-UWW-ODAC).[66] The 2023 round of EDF calls, on the other hand, focuses on ASW and seabed warfare capabilities (EDF-2023-DA-UWW-ASW) and future MCM (EDF-2023-DA-UWW-MCMC).[67]

NATO too plays a major role in spurring international cooperation in the underwater domain. Important work is being done in terms of STANAGs when it comes to UUVs,[68] but the Alliance can also count on some relevant joint initiatives. The La Spezia-based CMRE, for instance, is a critical facility under NATO's Science and Technology Organisation (STO) dedicated to R&D in the underwater domain. While it started as a ASW research centre in the 1950s, today it also pursues research in big data and UUVs.[69] CMRE is also an important stakeholder in MUS initiative. Another NATO institution is the Kiel-based Centre of Excellence for Operations in Confined and Shallow Waters (CoE CSW). Here, Italian and German experts in the CoE's concepts and doctrine branch are tasked with the oversee research in underwater operations.[70] The CoE regularly participates in REPMUS, an annual NATO exercise focused on experimenting with UUVs.[71] Finally, the most recent addition to NATO's underwater efforts have been the Critical Undersea Infrastructure Coordination Cell, established in February 2023 in the wake of the Nord stream sabotage, and subsequently a maritime centre for the security of critical underwater infrastructures. While the Cell is a civilian platform to exchange information and good practices to identify possible threats to UCIs and enable more effective planning,[72] the centre will aim to enhance cooperation among allies and with the industry, while also setting up a new surveillance system for monitoring UCIs in the Trans-Atlantic region.[73]

[65] European Commission, *OCEAN 2020: The EU's Largest Collaborative Defence Research Project under the PADR Successfully Completed*, 27 October 2021, https://europa.eu/!3cKVf7.

[66] European Commission, *2022 Call Topics Description. Annex 3 to the Commission Implementing Decision on the Financing of the European Defence Fund*... (C/2022/3403), 25 May 2022, https://defence-industry-space.ec.europa.eu/system/files/2022-05/C_2022_3403_3_EN_annexe%203.pdf.

[67] European Commission, *2023 Call Topics Description. Annex 3 to the Commission Implementing Decision on the Financing of the European Defence Fund*... (C/2023/2296), 29 March 2023, https://defence-industry-space.ec.europa.eu/system/files/2023-03/C_2023_2296_EDF%202023%20Call%20topic%20descriptions.pdf.

[68] See chapter 2.3 in this study.

[69] NATO CMRE, *2022 Annual Report*, 21 June 2023, https://www.cmre.nato.int/research/publications/technical-reports/special-publications/1701-cmre-ar-2022.

[70] CoE CSW website: *The COE CSW Working Structure*, https://www.coecsw.org/our-coe/our-structure.

[71] See chapter 2.3 in this study.

[72] Lee Willett, "NATO Steps Up Response to 'Clear and Present' Undersea Infrastructure Risk", in *Naval News*, 16 May 2023, https://www.navalnews.com/?p=44901.

[73] Gabriele Carrer, "Cosa farà il centro Nato per le infrastrutture sottomarine", in *Formiche*, 20 giugno 2023, https://formiche.net/?p=1562304.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

4. Germany

by Michelangelo Freyrie

Germany is considered a world-leading player when it comes to the underwater domain. The country has featured prominently in this segment for more than a century, with German-made SSKs dominating international markets. Its companies, from shipbuilders such as ThyssenKrupp Marine Systems (TKMS) up to suppliers of electronic components, play a major role in the research and production of new submarine classes. This puts German know-how, technologies, and production capacities at the forefront of the global race to acquire new and modernised capabilities in the underwater domain. The recent proliferation of UUVs and the attacks on the Nord Stream pipelines have contributed to a renewed interest in military operations below the surface and are indicative of the challenges the German Navy and industry will have to face both in littoral and oceanic waters.

4.1 Nord Stream sabotage as a wakeup call

The Nord Stream sabotage has put the underwater dimension in the spotlight of German maritime concerns. In the aftermath of the attack, numerous authors have pointed to Berlin's lack of both adequate procedures and technological capabilities to react to such events, not least due to a lack of clear subdivision of competencies in the protection of UCI (*Untersee-KRITIS* in German).[1] Crucially, the protection of critical infrastructures in the North and Baltic seas does not fall within the remit of the MoD, but is rather a task of the border and federal police forces.[2]

This does not mean that Germany is unaware of the strategic importance of the underwater environment and of seabed warfare. Again, the protection of seabed and seaborne infrastructures has attracted much policy interest in the wake of the Nord Stream events. Concretely, the sabotage has prompted Germany and Norway, one of Berlin's closest partners when it comes to underwater capabilities, to ask NATO to set up a hub for the protection of such critical, and vulnerable, targets.[3] The result has been the establishment of the Critical Undersea Infrastructure Coordination Cell at NATO's Brussels headquarters, initially led by a retired German military official, which aims to streamline civilian and military efforts in this domain.[4]

---

[1] Jonas Franken, "Kaum geschützt und vernachlässigt: Deutschlands Untersee-KRITIS", in *49security*, 30 November 2022, https://fourninesecurity.de/en/2022/11/30/kaum-geschuetzt-und-vernachlaessigt-deutschlands-untersee-kritis.

[2] German Parliament, *Antwort der Bundesregierung: Angriffe auf kritische Infrastrukturen unter See* (Drucksache 20/4170), 24 October 2022, p. 4, https://dserver.bundestag.de/btd/20/041/2004170.pdf.

[3] "Germany, Norway Seek NATO-Led Hub for Key Undersea Structures", in *The Defense Post*, 1 December 2022, https://www.thedefensepost.com/2022/12/01/germany-norway-nato-undersea-structures.

[4] For an analysis of NATO's role in UCI monitoring and protection, see chapter 1 of this study.

The German Navy (*Deutsche Marine*) is also starting to develop its own capabilities to face the changing threat landscape. The 2023 strategic document "Navy Objectives for 2035" (*Zielbild für die Marine ab 2035*) describes the marine depths (defined as "*Teildimension*", partial dimension, a term which implies it being part of the maritime domain) as rapidly growing in importance.[5] One of the main issues as stated by the document is that "even in peacetime, [...] is difficult to attribute underwater attacks on civilian and military targets to a responsible party".[6] As such, the document broadly outlines the priorities that the German Navy will need to pursue over the next decade: sensors and AI applications to establish underwater situational awareness, as well as UUVs and next generation submarines.[7] More details are expected once the upcoming National Security Strategy will provide a basis to develop a new top-level strategic document for the *Deutsche Marine* (*Dachdokument Marine*).[8]

Since reflections are still ongoing, the defence budget for 2023 does not foresee any new procurement projects for the underwater *Teildimension*. Still, expenditures for the upcoming U121CD-class submarines and the purchase of IDAS air defence systems for submarines will be financed via the new 100-billion-euro Special Fund for the Armed Forces set up in the wake of Chancellor Scholz's *Zeitenwende* speech.[9]

4.2 Submarine fleet and projected upgrades

The expected adjustments will also affect current fleet structures and balance. The German submarine forces are organised within the *1. Ubootgeschwader* (1st U-Boot Squadron), which also holds a repurposed *Elbe*-class replenishment ship specialised in submarine support.[10] The German Navy currently operates six U212A-class AIP SSKs, which are projected to be substituted with six-to-nine new U212CD-class units over the next decades.

The U212A is a joint Italian-German programme led by TKMS and Fincantieri, developed in the 1990s and which initially accommodated the operational requirements of both the German and Italian navies. This commonality decreased over the course of the years, leading to divergent paths for the two partners:

[5] German Inspector of the Navy, *German Navy Objectives for 2035 and beyond. Fit for the Future: Towards Unmanned Systems and Artificial Intelligence*, 20 April 2023, https://www.bundeswehr.de/en/organization/navy/news/german-navy-objectices-2035-plus-5625058.

[6] Ibid., p. 5.

[7] Ibid.

[8] German Inspector of the Navy, *Commander's Intent: Absicht 2023*, 19 April 2023, https://www.bundeswehr.de/de/organisation/marine/aktuelles/absicht-inspekteur-2023-5613320.

[9] German Federal Government, *Bundeshaushaltsplan 2023. Einzelplan 14. Bundesministerium der Verteidigung*, November 2022, p. 72 https://www.bundeshaushalt.de/static/daten/2023/soll/epl14.pdf.

[10] Bundeswehr website: *1 Submarine Squadron*, https://www.bundeswehr.de/en/organization/navy/organization/flotilla-1/1-submarine-squadron.

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

while Italy is currently developing the U212 NFS (which is already assessed to be "significantly different" compared to its German counterpart),[11] TKMS and Germany are pursuing the U212CD together with Norway.[12] The first U212CD vessels are planned to be delivered to the German Navy in 2032. The current contract only foresees two units for Germany,[13] for an overall cost of the programme, which also includes four vessels for the Norwegian Navy as well as logistical and training support, amounts to 5.5 billion euro. The common programme bureau will be built in Kiel, Germany.[14]

With an expected surface displacement of 2,500 tons, U212CD will be far larger than both the U212A (1,450 tons)[15] and U212 Near Future Submarine (NFS, 1,600 tons). The joint venture includes Kongsberg Defence & Aerospace, TKMS and its subsidiary Atlas Elektronik. Like its precursors, the U212CD will sport an air independent propulsion.[16] A unique feature of U212CD will be the high level of attention to stealth given by German designers, with the ambition of making the vessel less detectable even to active sonar. German engineers expect to significantly reduce the vessel's sonar signature by relying on flat sloping sides, which is expected to reflect incoming sonar signals in a narrower beam than the more diffused beams reflected by cylindrical designs. This approach on submarines had been explored by German designers in World War 2 and experimentations had been carried out by Lockheed Martin while working on the F-117A Nighthawk stealth fighter, which utilises a similar concept to decrease its radar signature.[17]

Finally, U121CD will also carry the new ORCCA Combat Management System, a modular system designed for upgrading all in-service and future non-nuclear submarine classes of TKMS.[18] In theory, the U121CD could also be equipped with Kongsberg's anti-ship missile NSM missiles.[19] Although the *Deutsche Marine* is currently procuring NSM Bloc 1A systems for its frigates,[20] as recently as in 2020

[11] Interview, 23 March 2023.

[12] For an analysis on Italian planning regarding the U212 NFS, see chapters 6 and 7 of this study.

[13] Marcus Bredick, "Vertrag für U 212CD unterzeichnet", in *MarineForum Online*, 9 July 2022, https://marineforum.online/vertrag-fuer-u-212cd-unterzeichnet.

[14] Bundeswehr, *New Submarines and Antishipping Missiles for the Navy*, 9 July 2022, https://www.bundeswehr.de/en/organization/equipment/news/german-norwegian-submarines-and-antishipping-missiles-5217908.

[15] Bundeswehr website: *U-Boot-Klasse 212 A*, https://www.bundeswehr.de/de/ausruestung-technik-bundeswehr/seesysteme-bundeswehr/u-boot-klasse-212-a.

[16] Luca Peruzzi, "Europe Leads the Conventional Submarine Segment", in *EDR Magazine*, No. 60 (November/December 2021), p. 14-21, https://issuu.com/edrmag/docs/edr_60-2b_web-1/s/13960318.

[17] H.I. Sutton, "Radical New Stealth Submarine, Type-212CD, Will Be Much Larger", in *Naval News*, 14 September 2021, https://www.navalnews.com/?p=25576.

[18] Xavier Vavasseur, "TKMS & Kongsberg Unveil 'ORCCA' New Combat Management System for Submarines", in *Naval News*, 6 September 2019, https://www.navalnews.com/?p=6351.

[19] Xavier Vavasseur, "Norway and Germany Reach Agreement on 212CD Submarine Contract", in *Naval News*, 23 March 2021, https://www.navalnews.com/?p=20739.

[20] Federal Ministry of Defence, *Umfangreiche Beschaffungen für die Deutsche Marine*, 24 June 2021, https://www.bmvg.de/de/aktuelles/umfangreiche-beschaffungen-fuer-die-deutsche-

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

the acquisition of a submarine-based version of NSM was not in the cards in Germany,[21] and no such indication exists in current budget plans.

4.3 UUV capabilities and outlook

Reflections are still ongoing on a potential expansion of Germany's UUVs fleet for MCM tasks, with a further addition of six LUUVs for reconnaissance missions also mentioned as an objective.[22] These would likely be in service with the *3. Minensuchgeschwader* (3rd Mine Detection Squadron) from the *Einsatzflotille* 1 (Operational Flotilla 1), tasked with ship protection and underwater de-mining.[23] The unit already utilises the Remus 100 AUV for reconnaissance purposes,[24] while the destruction of mines is carried out either with the *Seefuchs* UUV (built by Atlas Elektronik)[25] or three remotely-operated *Seehund* surface vessels.[26]

The Planning Office of the *Bundeswehr* has articulated its own strategic and technical outlook on the matter of UUVs in a 2017 report, which formulates its expectations on the development of such systems. In the short term, the *Bundeswehr* does not envisage any major role for UUVs beyond oceanographic mapping and MCM.[27] However, advances in artificial intelligence led the authors of the 2017 report to speculate that from 2037 onwards it will be possible to deploy fully autonomous UUVs which could act as force multipliers in a stand-alone manner, assuming it will be compatible with Germany's strict legal and ethical rules on autonomous systems.[28]

Some of the development projects currently being pursued are expected to put Germany on the map of UUV production with some new indigenous designs. TKMS is reported to be pursuing the construction of a massive mothership XLUUV for transport and, potentially, military uses.[29] Moreover, in 2021 the German

marine-5099106.

21 German Parliament, *Antwort der Bundesregierung: Stand des Rüstungsprojektes U-Boot 212CD* (Drucksache 19/22412), 15 September 2020, https://dserver.bundestag.de/btd/19/224/1922412.pdf.

22 Hans Uwe Mergener, "Langfristplanung der Marine – Neues Zielbild für die Zeit ab 2035 gibt Einblick in die zukünftige Flottenstruktur", in *Europäische Sicherheit und Technik*, 29 March 2023, https://esut.de/2023/03/fachbeitraege/40786.

23 Bundeswehr, *Northern Coast 21 – Die Unterwasserspezialisten*, 7 October 2021, https://www.bundeswehr.de/de/organisation/marine/aktuelles/die-unterwasserspezialisten-5226554.

24 Ibid.

25 Yann Bombeke, "Multitools für den Minenkampf", in *DBwV Blickpunkt*, 6 March 2020, https://www.dbwv.de/aktuelle-themen/blickpunkt/beitrag/multitools-fuer-den-minenkampf.

26 Deutscher Marinebund website: *„Seehunde" zum Minenräumen*, https://deutscher-marinebund.de/berichtedmb/seehunde-zum-minenraeumen.

27 Bundeswehr Planning Office, *Future Topic: nmanned Underwater Vehicles. Sachstand und Perspektiven für militärische Unterwasserwirkmitte*l, 2017, p. 12, https://www.bundeswehr.de/resource/blob/140478/ced16e7db8129001e1f020424a617d4e/ft-uuv-data.pdf.

28 Ibid, p. 25.

29 Thyssenkrupp Marine Systems website: *MUM – Modifiable Underwater Mothership*, https://www.thyssenkrupp-marinesystems.com/en/products-services/innovations/mum-modifiable-underwater-mothership.

© 2023 IAI

ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023

Federal Ministry for Economic Affairs also allocated 12 million euro for the development of new UUVs to carry out ISR and surveillance missions around deep sea infrastructures.[30]

4.4 Germany's conventional submarine production

Germany is a leading nation when it comes to underwater combat systems, and as such has a strong track record in terms of exports. From the 1960s onwards, national shipyards have built and exported more than 120 vessels, especially from the U209 family.[31] More recently, German sales have also included second-hand U206As to Colombia (2012), conventional engines for the French-Spanish *Scorpène* class (2017), sonars for indigenous Korean vessels and U218 models for Singapore (2017).[32] Export models also include the U214 model, a long range version of the U212 sold, among others, to Greece, South Korea, Pakistan and Turkey.[33] The U214 is a typical example of Germany's broad offer in terms of export models. A younger design than the U212, the U214 is larger and can reach lower depths thanks to different hull materials.[34] Larger versions of the U214, such as the U216 designed specifically to be exported to countries demanding larger SSKs such as Australia, India and Canada,[35] are also considered competitive in the Indo-Pacific region.[36] Within the framework of Germany's renewed interest in the Indo-pacific, Berlin is also actively pursuing a sale of six Air Independent Propulsion submarines to India valued at 5.2 billion US dollars.[37] Germany is among the few countries employing AIP, which is considered a must-have for India's Project-75(I) project alongside other criteria such as technology transfers.[38] TKMS has re-entered the fray thanks to a perspective of a government-to-government deal between Berlin and New Delhi, although no details are known regarding which submarine model TKMS would build together with local partners.[39]

---

30 "Germany Funds AUV Development", in *Sea Technology*, 17 May 2021, https://wp.me/p6DV9z-47s.

31 War and Peace portal: *German Submarine Exports*, https://warpp.info/en/m5/articles/german-submarine-exports.

32 Stockholm International Peace Research Institute: *SIPRI Arms Transfers Database*, https://www.sipri.org/databases/armstransfers.

33 "U212/U214 Submarines", in *Naval Technology*, 31 July 2020, https://www.naval-technology.com/?p=4744.

34 H.I. Sutton, "Australian Navy Eyes German Type-214 Submarine?", in *Covert Shores*, 27 May 2021, http://www.hisutton.com/Australian=Submarine-Options-Type-214.html.

35 Navy Recognition website: *Type 216 / U-216 Conventional AIP Submarine (SSK)*, http://navyrecognition.com/mobile/index.php/oceania/australia/submarines/264-type-216-u-216-conventional-submarine-ssk-aip-tkms-hdw-submarine-class-216-howaldtswerke-deutsche-werft-thyssenkrupp-marine-systems-royal-australian-navy-datasheet-pictures-i.

36 Gabriel Honrada, "German, Swedish Subs Better for Taiwan, Australian Needs", in *Asia Times*, 26 January 2022, https://asiatimes.com/?p=684124.

37 Rupam Jain, Andreas Rinke and Krishn Kaushik, "Germany to Pursue $5.2 bln Submarine Deal with India during Scholz Trip - Sources", in *Reuters*, 24 February 2023, https://www.reuters.com/world/germany-pursue-52-bln-submarine-deal-with-india-during-scholz-trip-sources-2023-02-24.

38 GlobalSecurity.org: *Project 75(I)*, https://www.globalsecurity.org/military/world/india/project-75-i.htm.

39 Dinkar Peri, "Germany Expected to Present Government-to-Government Proposal for Sale

© 2023 IAI

ISSN 2280-6164

The main German producer is TKMS, which has a strong presence in northern Germany, and owns a submarine shipyard in Kiel and also various subsidiaries, such as Atlas Elektronik GmbH, and Howaldtswerke-Deutsche Werft GmbH. Through these companies, TKMS is able to cooperate with a plethora of sector-leading German firms, such as Siemens on the development of seaworthy composite materials.[40] In Kiel, TKMS has also carried out major investments to upgrade its production facilities in order to start working on the U121CD from 2023 onwards.[41] This is part of a greater trend that will lead to significant spare capacity in its submarine production. In 2022, after the insolvency of civilian shipyard MV Werfen, the Federal Government took over the company's facilities at Rostock, reserving them for maintenance of the German Navy, while TKMS purchased the Wismar shipyards for submarine production. Both locations are assessed as having a maximum productive capacity that far outstrips current projects and orders.[42]

Paradoxically, despite TKMS' presence on the global markets, it is likely that its parent company Thyssenkrupp will eventually opt to sell its naval division. Despite TKMS' recent, positive financial track record (in 2022 it generated 1.8 billion euro in sales and earnings of 32 million before interests and taxes),[43] the company has been caught in a long-winded debt restructuring process of the conglomerate. Indeed, the Thyssenkrupp industrial conglomerate, of which TKMS is part, reportedly lacks the liquidity to provide enough resources to invest in new disruptive technologies, essential to keep TKMS competitive on the global market.[44] While investor pressure on Thyssenkrupp's management[45] has made the corporate spin-off of TKMS all but certain,[46] doubts remain over whether the division will be bought by foreign suitors.[47]

of Submarines to India", in *The Hindu*, 4 April 2023, https://www.thehindu.com/news/national/article66699154.ece.

[40] Siemens Resource Center website: *Submarine Builder Reduces Manufacturing Time and Enhances Quality of Composite Parts*, https://resources.sw.siemens.com/en-US/case-study-howaldtswerke-deutsche-werft.

[41] Thyssenkrupp Marine Systems, *Foundation Stone Laid for New Shipbuilding Hall*, 16 September 2021, https://www.thyssenkrupp-marinesystems.com/en/newsroom/press-releases/press-detail-page/foundation-stone-laid-for-new-shipbuilding-hall-120439.

[42] Jean-Pierre Ziegler, "Wie die Angst vor Russland den deutschen Schiffbau rettet", in *Der Spiegel*, No. 18/2023 (1 May 2023).

[43] Patricia Nillson and Will Louch, "ThyssenKrupp Revives Sale of Submarine and Marine Systems Unit", in *Financial Times*, 31 March 2023, https://www.ft.com/content/d3b96ace-37ad-4b18-b3b4-be7b3b2f0dc6.

[44] Caspar Busse and Thomas Fromm, "Warum Thyssenkrupp seine Kriegsschiffe loswerden will", in *Süddeutsche Zeitung*, 8 April 2023.

[45] Christoph Steitz and Tom Kaeckenhoff, "Thyssenkrupp Investor Demands Fast Defence Division Disposal", in *Reuters*, 2 February 2023, https://www.reuters.com/markets/europe/thyssenkrupp-top-20-investor-calls-sale-defense-division-2023-02-03.

[46] "Thyssenkrupp Preparing to Spin Off Shipyard Division – Handelsblatt", in *Reuters*, 3 April 2023, https://www.reuters.com/business/thyssenkrupp-preparing-spin-off-shipyard-division-handelsblatt-2023-04-03.

[47] A corporate spin-off consists in a company splitting off a section as a separate business, often

Other notable companies in the German underwater segment include Hensoldt, which will provide optronics equipment for the U212CD. The solution provided will allow the adoption of a hull-penetrating digital system instead of a periscope-based traditional antenna.[48] Foreign actors also play a major role in the German defence industrial base. Spanish company Indra, for instance, will provide satellite communication systems to upgrade the data transmission capabilities of two U212.[49] Non-EU companies also figure as important suppliers: Turkish Roketsan has participated to the development of the IDAS air defence system for submarines.[50]

in order to sell it. See: Martin Murphy and Arno Schütze, "Thyssen-Krupp will Werftentochter mit Wettbewerber verschmelzen", in *Handelsblatt*, 17 February 2022, https://www.handelsblatt.com/28073940.html.

48 "Next-Generation Optronics Suite for German-Norwegian Submarines", in *Defense Advancement*, 19 January 2022, https://www.defenseadvancement.com/news/next-generation-optronics-suite-for-german-norwegian-submarines.

49 Indra, *Germany to Implement Indra's Satellite Communications System in Two U-212 Submarines*, 1 October 2009, https://www.indracompany.com/pt-br/node/46244.

50 "Roketsan, ThyssenKrupp and Diehl Team up for IDAS Missile Programme", in *Naval Technology*, 14 May 2013, https://www.naval-technology.com/?p=13819.

ISSN 2280-6164

5. The Indo-Pacific and the underwater environment

by Elio Calcagno

During the last decade, and at an accelerating pace, the Indo-Pacific has been transforming into the main stage for geostrategic competition between the US and China. This macro-region generates over one third of global economic activity, a figure that will grow to 50 per cent by 2040.[1] Furthermore, by using the broadest possible definition, which extends from the Western Indian Ocean, including the Gulf, all the way to the Western coast of the United States, the Indo-Pacific is home to four of the largest economies in the world: the US, China, Japan and India. From a maritime perspective, it contains nine out of ten of the world's busiest seaports and some of the most crucial choke points, such as the Straits of Malacca and Hormuz, and through its busy SLOCs transits 60 per cent of global seaborne trade. One third of that trade volume passes through the South China Sea, which through the decades has become a hotspot of diplomatic and military tensions between China and littoral states such as Vietnam, Malaysia, Indonesia and the Philippines.[2]

The Indo-Pacific regional security environment is characterised by the rise of China and its military capabilities, the tensions about status of Taiwan, and a concurrent general drive by most regional countries to bolster their militaries through the acquisition of equipment across the board, with particular attention to the maritime domain. This is also evident in Southeast Asia, which collectively doubled military spending between 1992 and 2012, mainly on the back of large acquisitions of naval warfare-related platforms and equipment, including submarines. In a high-intensity conflict scenario sparked by Chinese aggression in the Taiwan Strait or the South China Sea, submarines could play a decisive role. As a result, an analysis of the different approaches to underwater warfare capabilities taken by South Korea, Japan, Australia and Southeast Asian states, reveal the importance of the underwater domain in the Indo-Pacific theatre.

5.1 China: An underwater power in the making

China's perceived vulnerability to lighting combined arms attack by the US has pushed it to develop a 'way of war' that focuses on disrupting enemy infrastructure and engaging its vessels at range while also employing uncrewed systems as force multipliers in the face of a stronger conventional force.[3] At the same time,

[1] Canada Government, *Canada's Indo-Pacific Strategy*, Ottawa, 2022 https://www.international.gc.ca/transparency-transparence/indo-pacific-indo-pacifique/index.aspx?lang=eng.

[2] Anh Tuan, "Maritime Security in the Indo-Pacific: Mixed Opportunities and Challenges from Connectivity Strategies", in Christian Echle et al. (eds), *Responding to the Geopolitics of Connectivity. Asian and European Perspectives*, Singapore, Konrad-Adenauer-Stiftung, 2019, p. 125-137, https://www.kas.de/en/web/politikdialog-asien/panorama/detail/-/content/responding-to-the-geopolitics-of-connectivity.

[3] Michelangelo Freyrie, "Russia and China", in Alessandro Marrone and Elio Calcagno (eds), "Naval Combat Systems: Developments and Challenges", in *Documenti IAI*, No. 23|01 (January 2023), p. 27-

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

the Chinese military has invested greatly in developing and fielding A2/AD capabilities, in the form of long-range anti-ship and cruise missiles, that would significantly complicate the US Navy's ability to operate freely near Chinese coasts and installations at least up until the First Island Chain (See Figure 2).[4] As a result, the US may be forced to rely more heavily on nuclear attack submarines in order to confront the PLAN beyond the Second Island Chain.

Figure 2 | Map depiction of the First and Second Island Chains

Source: US Department of Defense, *Military Power of the People's Republic of China. Annual Report to Congress*, 2009, p. 18, https://apps.dtic.mil/sti/citations/ADA495514.

While historically China has lacked cutting-edge underwater and submarine capabilities, it is becoming increasingly clear that a very significant drive is ongoing in order to turn the country into a leading power beneath the surface. The

31, https://www.iai.it/en/node/16476.

[4] Jon Lake, "China's Stealthy Area Denial", in *Asian Military Review*, Vol. 30, No. 5 (September/October 2022), p. 26-30, https://www.asianmilitaryreview.com/?p=14493.

ISSN 2280-6164

PLAN has at its disposal a large fleet composed of SSKs, SSNs and SSBNs, which according to estimates could reach a total number of 76 units in service by 2030.[5] However, amid a staggering shipbuilding effort both in terms of sheer numbers and quality of the newly-launched surface ships,[6] the PLAN is simultaneously prioritising the modernisation of its submarine force rather than a radical growth in numbers.[7]

The country still lags behind the West when it comes to nuclear submarines. A gap that is especially obvious in terms of quieting technology, given that current Chinese SSNs and SSBNs are estimated to be as noisy as Soviet counterparts in the 1970s.[8] Nevertheless, Beijing has made considerable strides in the field of conventional submarines. In fact, the Type-039A *Yuan*-class conventional submarines are much quieter than previous designs and the first Chinese submarines relying on AIP propulsion – today they make up the bulk of the PLAN's conventional submarine force.[9] This class first entered service in the second half of the 2010s with four units, which were joined by fourteen more belonging to the upgraded Type-039B over the following decade.[10] Since 2021, the navy has introduced a further upgrade in the Type-039C, of which little is known besides the fact that its sail has an angled design in some ways similar to Sweden's A-26, though for unknown purposes.[11] This latest iteration of the *Yuan* class has anti-ship operations as its primary missions, so it is likely that it will be equipped with anti-ship missiles on top of torpedoes, such as for instance the YJ-18B supersonic anti-ship cruise missiles.[12]

China's production and technological know-how has improved to the point that Beijing is now striking conventional submarine export deals in a market historically dominated by Germany, Russia, and France and now increasingly crowded. Pakistan has signed a deal for eight Type-039B submarines, four of which will be built in China, while Bangladesh and Myanmar have received respectively two new and one second-hand Type-035 Min-Class submarines.[13] Beijing has also been attempting to sell Yuan-Class units to Thailand as well as Nigeria, suggesting

[5] Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress", in *CRS Reports*, No. RL33153 (15 May 2023), https://sgp.fas.org/crs/row/RL33153.pdf.

[6] Sam LaGrone, "Pentagon: Chinese Navy to Expand to 400 Ships by 2025, Growth Focused on Surface Combatants", in *USNI News*, 29 November 2022, https://news.usni.org/?p=99253.

[7] Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities", cit.

[8] Mike Sweeney, "Submarines Will Reign in a War with China", in *USNI Proceedings*, Vol. 149/3/1441 (March 2023), https://www.usni.org/node/59958.

[9] SeaForces.org: *Type 039A/B/C Yuan class Attack Submarine - SSK/AIP*, https://www.seaforces.org/marint/China-Navy-PLAN/Submarines/Type-039A-Yuan-class.htm.

[10] Ibid.

[11] See chapter 3 of this study for an analysis of Sweden's submarine capabilities.

[12] H.I. Sutton, "Submarine Guide: Chinese Navy's Latest Type-039C Yuan Class", in *Covert Shores*, 8 July 2021, http://www.hisutton.com/Chinese-Type-039C-Yuan-Class-Submarine.html.

[13] H.I. Sutton, "China's Surprise Submarine Move Shows Its Growing Power", in *Naval News*, 29 December 2021, https://www.navalnews.com/?p=28500.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

a significant effort to occupy an SSK market where Russia does not currently offer AIP options.[14]

As it pushes to become a more significant underwater player, Beijing is also putting efforts into building solid UUV capabilities,[15] as demonstrated by the HSU-001 AUV that was unveiled in 2019. Although little is known about its capabilities officially, as indeed whether it is already in service, pictures suggest that it was designed for long range patrols and is equipped with a sonar similar, but much smaller, than those used in larger crewed submarines.[16] More recent satellite imagery has indicated that the PLAN may be testing even larger UUVs, though such reports remain unconfirmed.[17]

In line with other naval powers around the world, China is operating the largest and most active fleet of hydrographic survey ships in the Indo-Pacific, with over 25 active units under the flag of the Ministry of Natural Resources. In recent years they have carried out huge campaigns in the South China Sea and beyond, sometimes turning their AIS off to avoid being tracked.[18]

5.2 South Korea and Japan

5.2.1 Submarine capabilities

Japan and South Korea are veritable submarine force heavyweights, with 22 and 20 active units respectively, all conventionally powered, including a ballistic missile submarine in service with the Republic of Korea Navy (ROKN).[19] Both countries share the challenge of being geographically close to North Korea as well as the Chinese mainland, and consequently to its land-based A2/AD umbrella. In such an environment, submarines offer greater survivability in case of high-intensity conflict, as the results of a 2023 CSIS war-game suggest.[20]

---

[14] H.I. Sutton, "African Navies' Submarine Capabilities 2021", in *Covert Shores*, 12 November 2021, http://www.hisutton.com/African-Navies-Submarines.html; H.I. Sutton, "China's Surprise Submarine Move Shows Its Growing Power", cit.

[15] Prakash Panneerselvam, "Unmanned Systems in China's Maritime 'Gray Zone Operations'", cit.

[16] H.I. Sutton, "China Navy Reveals New Large Underwater Robot Which Could Be a Game Changer", in *Forbes*, 1 October 2019, https://www.forbes.com/sites/hisutton/2019/10/01/china-reveals-new-robot-underwater-vehicle-hsu-001.

[17] H.I. Sutton, "China's New Extra-Large Submarine Drones Revealed", cit.

[18] H.I. Sutton, "Chinese Survey Ship Caught 'Running Dark' Give Clues to Underwater Drone Operations", in *USNI News*, 16 January 2021, https://news.usni.org/?p=82798; Asia Maritime Transparency Initiative (AMTI), "What Lies Beneath: Chinese Surveys in the South China Sea", in *AMTI Features*, 1 March 2022, https://amti.csis.org/what-lies-beneath-chinese-surveys-in-the-south-china-sea; AMTI, "A Survey of Marine Research Vessels in the Indo-Pacific", in *AMTI Features*, 16 April 2020, https://amti.csis.org/a-survey-of-marine-research-vessels-in-the-indo-pacific.

[19] "South Korea Submarine Capabilities", in *NTI Fact Sheets*, 7 October 2022, https://www.nti.org/?p=21288; "Japan Submarine Capabilities", in *NTI Fact Sheets*, 3 March 2023, https://www.nti.org/?p=21210.

[20] Mark F. Cancian, Matthew Cancian and Eric Heginbotham, "The First Battle of the Next War: Wargaming a Chinese Invasion of Taiwan", in *CSIS Reports*, January 2023, https://www.csis.org/

ISSN 2280-6164

Thanks to a 2011 export deal with Indonesia, South Korea became one of the few countries world-wide to have exported submarines.[21] Hyundai Heavy Industries and Daewoo Shipbuilding & Marine Engineering (DSME) constitute the backbone of the South Korean shipbuilding industry and have built all ROKN submarines in service today, always based on German designs. The older *Chang Bogo*-class, nine in total, are an adaptation of the Type-209 design, whereas the more recent *Son Won-II*-class submarines are based on the Type-214.[22] The Korean navy has commissioned the first unit of the *Dosan Ahn Changho* class (also known as KSS-III) in 2022.[23] These are also based on the Type-214, but are much larger, at over 3,000 tonnes, and have VLS tubes for cruise and ballistic missiles as well as much increased range and endurance.[24]

Japan's submarine fleet is simultaneously large and exceedingly 'young' on average. Three separate classes are now in service with the Japanese Maritime Self-Defence Force (JMSDF), with the oldest submarines belonging to the *Oyashio* class, the most senior having been commissioned only in 2000. Indeed, Japan has decommissioned the first of its *Oyashio* class after 25 years of service, when in most other navies service life for submarines can span over four decades.[25] In the coming years, the bulk of the JMSDF submarine force will be comprised of the *Sōryū* class. An upgrade to the *Oyashio* and first commissioned in 2009, it is large in size for a conventional submarine, with a submerged displacement of over 4,200 tons. Unlike their predecessors, these are powered by AIP units manufactured by Swedish company Saab Kockums.[26] Only the last two submarines in this class, launched after 2020, do not have AIP in favour of lithium-ion batteries manufactured by Japanese firm GS Yuasa – the first to do so in the world.[27] Japan is currently launching the first units of a third class of submarines, the *Tagei*, which are fitted with lithium-ion batteries and will replace the Oyashio-class submarines as they are decommissioned.[28] All JMSDF are capable of launching

node/68386.

21 Alexander M. Hynd and Max Broad, "Indonesia's Own Subs Conundrum", in *The Interpreter*, 17 February 2023, https://www.lowyinstitute.org/node/35178.

22 "KSS-III (Jangbogo-III) Class Attack Submarines, South Korea", in *Naval Technology*, 21 January 2022, https://www.naval-technology.com/?p=53697.

23 SeaForces.org: *Son Won-il Class (Type 214 / KSS-II) Submarine*, https://www.seaforces.org/marint/Republic-Korea-Navy/Submarine/Son-Won-il-class.htm.

24 SeaForces.org: *Dosan Ahn Changho Class (KSS-III) Submarine*, https://www.seaforces.org/marint/Republic-Korea-Navy/Submarine/Dosan-Ahn-Changho-class.htm.

25 Bradley Perrett, "How Japan Could Quickly Build up Its Submarine Force", in *The Strategist*, 18 April 2023, https://www.aspistrategist.org.au/how-japan-could-quickly-build-up-its-submarine-force.

26 "SS Soryu Class Submarines", in *Naval Technology*, 26 February 2021, https://www.naval-technology.com/?p=5727.

27 Raymond McConoly, "Soryu Class Submarine: Are They the Best Diesel-Electric Attack Submarines in the World?", in *Naval Post*, 15 August 2021, https://navalpost.com/?p=42879.

28 Mike Yeo, "Japan Commissioned First of New Submarine Class", in *Defense News*, 10 March 2022, https://www.defensenews.com/naval/2022/03/10/japan-commissioned-first-of-new-submarine-class.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

UGM-84 Harpoon anti-ship missiles from their torpedo tubes, though there have been reports that VLS capabilities are being considered in order to launch long-range land-strike and anti-ship cruise missiles.[29] Thanks to shipbuilding giants Mitsubishi Heavy Industries (MHI) and Kawasaki Shipbuilding Corporation, which build all Japanese submarines, the domestic industry is able to launch a submarine at the impressive tempo of roughly one per year, as it has done for two decades.[30] Despite this industrial capacity, technological excellence, and some interest by foreign navies in India and Australia, Japan is yet to export any submarines.[31]

5.2.2 Seabed warfare and UUVs

Though details on ongoing projects are mostly classified, the South Korean Navy has announced that UUV's are part of its vision for a "Smart Navy" and that a development programme is underway, which will start with the entry into service of a Remote Mine-hunting System (RMS) mainly intended for use along SLOCs, and capable of operating down to 200 metres for three to 20 hours. The RMS will be equipped with a side-scan sonar, underwater cameras and electro-optical sensors.[32]

The ROKN is already looking ahead to employing large and extra-large AUVs in ASW roles, initially through integration with crewed submarines (project "Navy Sea GHOST") and ultimately with the long-term aim of replacing crewed platforms.[33] DSME is playing a central role, together with the Hanwha Group conglomerate,[34] the navy and the Agency for Defence Development (ADD). In July 2022 the ADD conducted a successful operational demonstration of a large displacement anti-submarine AUV that will specialise in monitoring and tracking enemy submarines thanks to an endurance of 30 days, a cruising speed of ten knots and the ability to dive to 300 metres.[35]

Japan is also in the process of investing in uncrewed underwater technology, with the MoD including UUV technology in its priority development programmes in 2023.[36] The industry has already developed some particularly interesting solutions,

[29] Thomas Newdick, "Japan Wants to Arm Its Submarines with Long-Range Cruise Missiles: Report", in *The Drive*, 30 December 2021, https://www.thedrive.com/the-war-zone/43683.

[30] "Japan Submarine Capabilities", in *NTI Fact Sheets*, 3 March 2023, https://www.nti.org/?p=21210.

[31] Ibid.

[32] Sukjoon Yoon, "Make Way for South Korea's Underwater Drones", in *The Diplomat*, 19 February 2020, https://thediplomat.com/2020/02/make-way-for-south-koreas-underwater-drones.

[33] Juho Lee, "South Korea's DSME in Talks with ROK Navy to Develop UUVs for Combat Roles", in *Naval News*, 30 December 2022, https://www.navalnews.com/?p=41234; Sukjoon Yoon, "Make Way for South Korea's Underwater Drones", cit.

[34] The Hanwha Group has acquired DSME in 2022.

[35] Juho Lee, "South Korea's ASWUUV Conducts Operational Demonstration", in *Naval News*, 4 July 2022, https://www.navalnews.com/?p=35481.

[36] Dzirhan Mahadzir, "Japan Issues Military Equipment Wishlist that Includes Hypersonic Weapons, Unmanned Systems", in *USNI News*, 25 January 2023, https://news.usni.org/?p=100501.

such as for instance IHI Corporation's UUV unit for detecting mines, already delivered to the Coast Guard and slated to be acquired by the JMSDF. This is a true system of systems, with a mother ship on the surface sending commands to a semi-submersible unmanned surface vessel (SSUSV) through a satellite connection. The SSUSV then relays the commands to submerged AUVs, from which it receives a video feed that it then sends back to the mother ship.[37] This system of systems approach is already being designed into Japanese surface combatants, such as the new *Mogami*-class frigates, which will be equipped with MHI's OZZ-5 mine countermeasure UUV.[38]

5.3 Australia and the strategic implications of AUKUS

In September 2021 Australia renounced a deal with France for the supply of a new class of conventional-powered SSKs in favour of an Agreement, dubbed AUKUS, with the UK and US, for the supply of nuclear-powered hunter-killer submarines.[39] While the agreement also included a number of points relating to the development and sharing of military technologies, including EDTs, details on the path that would lead to the Royal Australian Navy commissioning SSNs have only began to materialise in early 2023. The US will first sell three *Virginia*-class nuclear attack submarines to Australia (pending US Congress approval), with an option for two more if necessary. This is meant as a temporary gap-filling measure as Canberra's aging *Collins*-class SSK's are retired in the coming decade and whilst the three countries work to develop the new *AUKUS*-class nuclear-powered submarines, which will combine a UK hull design and US technology, including in terms of propulsion and vertical launch systems. These SSNs are expected to enter service both with the UK and Australian navies in about two decades at least.[40]

AUKUS presents Australia with a capability that will revolutionise its deterrence outlook in the Indo-Pacific vis-à-vis China, giving its future submarine force unprecedented range, speed, and offensive capabilities, especially when considering the vast distances that would characterise any naval conflict taking place in the region. At the same time, AUKUS also has very significant strategic implications for the US' position in the Indo-Pacific. For instance, the most recent announcements regarding AUKUS have revealed that Australia will host forward-deployed American SSNs in Western Australia and build a new submarine base on

[37] Oishee Majumdar, "DSEI Japan 2023: IHI Develops UUV for Mine Detection", in *Janes*, 16 March 2023, https://www.janes.com/defence-news/news-detail/dsei-japan-2023-ihi-develops-uuv-for-mine-detection.

[38] Takahashi Kosuke, "Japan Commissions the Name-ship of New Mogami-Class Multirole Frigate", in *The Diplomat*, 29 April 2022, https://thediplomat.com/2022/04/japan-commissions-the-name-ship-of-new-mogami-class-multirole-frigate.

[39] Elio Calcagno, "Aukus: il fronte anglosassone nel Pacifico che esclude la Francia", cit.

[40] Sidharth Kaushal, "SSN-AUKUS: Opportunities, Risks and Implications", in *RUSI Commentaries*, 15 March 2023, https://rusi.org/explore-our-research/publications/commentary/ssn-aukus-opportunities-risks-and-implications; Australia, UK and USA, *Joint Leaders Statement on AUKUS*, 13 March 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/03/13/joint-leaders-statement-on-aukus-2.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

the East Coast. This will have tangible effects on the balance of power in the Indo-Pacific, including but not exclusively in the underwater domain. Indeed, the ability for US submarines to use SSN-capable facilities in Australia would relieve Guam of its current role as the most important support station for US units in the Pacific Ocean at a time when the island is within range of Chinese ballistic missiles. Since Guam also hosts the US Navy's two submarine tenders, the ability to operate from Australian bases, much farther from the Chinese coast, will allow the US to redistribute its support capabilities beyond a single point of failure.[41]

Despite the obvious opportunities that AUKUS promises to deliver, including much-needed economies of scale coming from the expanded manufacturing of systems and components that will come from three navies sharing a significant part of the inventory, many challenges lay ahead. From an Australian perspective, the industry and workforce will have to adapt quickly to building state-of the art SSNs and without much practice, as the last Collins-class unit was launched two decades ago.[42] Meanwhile, the current SSKs are not guaranteed to be in service long enough to ensure the continuity of a submarine capability until the first Virginia-class units are delivered to the RAN in the early 2030s, assuming there are no delays in their construction due to already-existing bottlenecks in the US ship-building industry.[43]

Despite UUVs not being mentioned as a priority in the 2023 Defence Strategic Review,[44] Australia is running a programme for the development of a XLUUV, known as Ghost Shark. In this context, the Australian Defence Force (ADF) has signed a contract worth 140 million US dollars with the US firm Anduril with the goal to co-fund three prototype extra-large autonomous underwater vehicles (XLAUV) in partnership with the Defence Science and Technology Group, a government agency.[45]

5.4 A growing submarine market in Southeast Asia

Taken as a group, Southeast Asian countries are one of the top military import markets in the world.[46] The four largest littoral states, Indonesia, Malaysia, Vietnam,

[41] Sidharth Kaushal, "SSN-AUKUS: Opportunities, Risks and Implications", cit.

[42] SeaForces.org: *Collins Class Submarine (SSG)*, https://www.seaforces.org/marint/Australian-Navy/Submarine/Collins-class.htm; Sidharth Kaushal, "SSN-AUKUS: Opportunities, Risks and Implications", cit.

[43] Tory Shepherd, "Mind the Capability Gap: What Happens if Collins Class Submarines Retire before Nuclear Boats Are Ready?", in *The Guardian*, 27 February 2023, https://www.theguardian.com/p/nb77q; Sidharth Kaushal, "SSN-AUKUS: Opportunities, Risks and Implications", cit.

[44] Australia Government, *National Defence: Defence Strategic Review 2023*, Canberra, 2023, https://www.defence.gov.au/about/reviews-inquiries/defence-strategic-review.

[45] Julian Kerr, "Anduril Progresses with Sydney R&D Facility", in *Australian Defence Magazine*, 22 September 2022, https://www.australiandefence.com.au/defence/sea/anduril-progresses-with-sydney-randd-facility.

[46] Evan A. Laksmana, "Why Is Southeast Asia Rearming? An Empirical Assessment", in Rafiq Dossani and Scott W. Harold (eds), *U.S. Policy in Asia — Perspectives for the Future*, Santa Monica, RAND

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

and the Philippines, have to different extents been modernising their navies. While it has been argued that China's more aggressive posture and expansionist actions in the South China Sea – for instance by constructing militarised artificial islands – may not be the main cause of such an effort, it should not be underestimated as a driver.[47] Indeed, although these countries' approach to Beijing's assertiveness in the early 2000s has been more accommodating, naval procurement trends in the last two decades show that deterrence in the naval and underwater domain has taken a prominent role in the respective naval strategies just as China's naval power has grown exponentially.[48]

Table 2 | Total submarine numbers and tonnage in service with largest Southeast Asian navies (2005 to 2030)

	Indonesia		**Malaysia**		**Philippines**		**Vietnam**	
Year	*Submarines*	*Tonnage*	*Submarines*	*Tonnage*	*Submarines*	*Tonnage*	*Submarines*	*Tonnage*
2005	2	2,780	0	0	0	0	2	488
2010	2	2,780	2	3,466	0	0	2	488
2015	2	2,780	2	3,466	0	0	4	5,172
2020	4	5,604	2	3,466	0	0	8	14,620
2025	5	7,926	2	3,466	1	1,733	8	14,620
2030	8	14,826	2	3,466	2	3,466	8	14,620

Source: Felix K. Chang, "Southeast Asian Naval Modernization and Hedging Strategies", cit.

Indonesia's submarine fleet is currently composed of four diesel-electric units belonging to two separate classes. The oldest is a *Cakra*-class submarine, originally built in Germany and acquired by Jakarta in 1981, and sister ship to the KRI Nanggala-402 which sunk in 2021 during an exercise.[49] Three modern *Nagapasa/Improved Chang Bogo*-class units make up the remainder of the Indonesian flotilla, having been commissioned between 2017 and 2021. Of the three Improved *Chang Bogo* (an upgrade of the ROKN version), the first two were built in South Korea by Daewoo Shipbuilding & Marine Engineering, and the newest in Indonesia by local shipbuilder PT PAL.[50] As tensions in the South China Sea simmer, the navy has announced plans to eventually field a total of twelve conventional attack

Corporation, 2018, p. 106-137, https://doi.org/10.7249/CF372.

[47] Ibid.

[48] Felix K. Chang, "Southeast Asian Naval Modernization and Hedging Strategies", in *The ASAN Forum*, 29 December 2021, https://theasanforum.org/?p=10962.

[49] Mike Yeo, "'Hodgepodge of Tech': What Makes Indonesia's Naval Buildup Vulnerable?", in *Defense News*, 13 February 2023, https://www.defensenews.com/smr/defending-the-pacific/2023/02/13/hodgepodge-of-tech-what-makes-indonesias-naval-buildup-vulnerable.

[50] Koya Jibiki, "Indonesia looks to Triple Submarine Fleet after Chinese Incursions", in *Nikkei Asia*, 30 May 2021, https://asia.nikkei.com/Politics/International-relations/Indo-Pacific/Indonesia-looks-to-triple-submarine-fleet-after-Chinese-incursions.

submarines. However, reports indicate that Indonesia may not be looking to South Korea for future acquisitions, instead opting to acquire two French-designed *Scorpéne*-class AIP-capable units, which will be built in Indonesia.[51] Should Jakarta's submarine build-up continue at this pace and up to the Navy's minimum requests, Indonesia is set to increase its potential for submarine operations substantially and near the standards of some middle-power, blue water navies.

Malaysia has acquired its first ever submarines rather recently, with two pre-AIP *Scorpène*-class units delivered to the Malaysian Navy in 2002. Amid budget constraints, but keen to enhance its deterrence capabilities in the South China Sea, Kuala Lumpur plans to acquire another two submarines by 2040.[52]

The Philippines, who are modernising their surface fleet, have submarine ambitions of their own and are working to create a submarine force for the first time in their history, with personnel already undergoing some training activities.[53] Indeed, the Philippine MoD is rumoured to have shortlisted a French (*Scorpène*) and a South Korean (improved *Chang Bogo*) option, though no official decision has been made as of time of writing.[54]

Currently, Vietnam boasts Southeast Asia's largest submarine fleet, with a total of six in service – all Russian-built. These Project 636M, improved Kilo-class units were purchased in 2009, in an acquisition that was then worth almost half of the total Vietnamese defence budget that year, demonstrating just how important this then-new capability was for Hanoi.[55] Vietnamese Kilos are equipped with modern Russian systems, including the 3M-14E Klub land attack cruise missiles and represent a rather formidable force in Southeast Asian waters.[56]

[51] Gabriel Honrada, "Jakarta Aims to Spend Big on French Submarines", in *Asia Times*, 9 May 2023, https://asiatimes.com/2023/05/jakarta-aims-to-spend-big-on-french-submarines.

[52] Collin Kho, "Royal Malaysian Navy Looking at Two More Submarines by 2040", in *Navy Recognition*, April 2018, https://navyrecognition.com/index.php/news/defence-news/2018/april-2018-navy-naval-defense-news/6110-royal-malaysian-navy-looking-at-two-more-submarines-by-2040.html.

[53] Xavier Vavasseur, "Philippine Navy Receives Submarine Training from France's DCI Group", in *Naval News*, 4 November 2022, https://www.navalnews.com/?p=39379.

[54] Chester Cabalza and Joshua Espeña, "Philippines' Subs: The AUKUS Inspiration", in *The Interpreter*, 4 October 2022, https://www.lowyinstitute.org/node/34430.

[55] Felix K. Chang, "Southeast Asian Naval Modernization and Hedging Strategies", cit.

[56] Truong Minh Vu and Nguyen The Phuong, "The Modernization of the Vietnam's People Navy: Grand Goals and Limited Options", in *AMTI Analyses*, 6 April 2017, https://amti.csis.org/modernization-vietnam-navy.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

© 2023 IAI

ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023

6. The Italian approach to the underwater domain

by Elio Calcagno and Alessandro Marrone

6.1 A country projected onto the sea and the need of a whole-of-government approach

Italy is a country projected onto the sea, on which it depends heavily for imports and exports as well as energy supplies. The country's coasts are over 8,000 kilometres long, equivalent to ca. 87 per cent of Italy's external borders, and represent a source of economic opportunity and a bridge to the world's oceans and global trade.[1] Indeed, 64 per cent of Italy's imports and 50 per cent of exports are transported by sea, while 480 million tons of goods transit the country's ports annually.[2] As recently as 2018, the Italian "blue economy" employed over half a million people, for a total turnover of 82.2 billion euro.

Italy's principal national interests revolve around the "wider Mediterranean" (*Mediterraneo allargato*) macro-region. It is a regional security complex[3] which spans from the Gulf of Guinea to the West, to the Gulf of Aden to the East through the Mediterranean basin and its littoral states, encompassing North Africa, Middle-East, the Sahel and the Horn of Africa. Furthermore, commercial ports throughout Italy are vital nodes for European trade as over 30 per cent of global container traffic transits the Suez Canal, combining for more than 1 trillion US dollars' worth of goods.[4]

Still, with a rising number of threats benefitting from technological progress and the development of emerging and disruptive technologies, maritime critical infrastructures in littoral waters and the open sea can also be vulnerable to sabotage and adversarial actions. At the same time, geopolitical competition is heavily affecting the wider Mediterranean too, with security and stability challenges as well as a kind of "territorialisation" of the Mediterranean basin via competing claims on economic exclusive zones by littoral countries. Being projected onto the sea and a bridge to the wider Mediterranean region means that Italy is also on the front line of what happens above and below the surface.

Broadly speaking, given the centrality of the sea for Italy's economy and national interests, both the naval and underwater domains require a whole-of-government approach. Prime Minister Giorgia Meloni's executive has given the sea renewed

[1] ISPRA, "Mare e ambiente costiero", in *Annuario dei dati ambientali 2014-2015*, 2015, p. 8, https://indicatoriambientali.isprambiente.it/pdf/tematiche-primo-piano-2014-2015.

[2] Fondazione Leonardo and Italian Navy, *Civiltà del mare. Geopolitica, strategia, interessi nel mondo subacqueo. Il ruolo dell'Italia*, cit.

[3] On the theory of regional security complex see: Barry Buzan and Ole Wæver, *Regions and Powers. The Structure of International Security*, Cambridge, Cambridge University Press, 2003.

[4] Ibid.

attention, including by creating a new Minister for Civil Protection and Sea Policies (*Ministro per la Protezione civile e le politiche del mare*)[5] responsible for inter-agency coordination of the eight ministries that historically have dealt with matters pertaining directly or indirectly to the sea and all related activities.[6] While it’s still too early to assess how this ministry will carve out a role with regard to those issues that are tied to the underwater environment, especially in terms of critical infrastructures and their security, a significant effort is observable in the drafting of a “Plan for the Sea” to be released in July 2023.

6.2 More critical and more vulnerable infrastructures to protect

While the majority of military underwater operations were once only possible to those navies that could afford to operate crewed submarines, the rise of increasingly capable UUVs (including both AUVs and ROUVs) has given access to this domain to a wider pool of non-military actors. Indeed, today seabed and deep-sea operations have been made accessible not only to armed forces but also law enforcement and private sector actors.[7] The latest developments in this direction have rendered surveillance, security, and defence of underwater infrastructures as well as SLOCs from underwater threats more salient than ever. This is particularly true for Italy. Thanks to its location at the very centre of the Mediterranean, the country is by nature a commercial and, potentially, energy hub in the region. As cables and pipelines become crucial arteries for the functioning of the global economy, Italy has been working to become a real hub also for telecommunications cables and energy pipelines.[8]

In terms of gas pipelines, Southern Italy is already a bridge to gas-producing countries through the Trans Mediterranean Gas Pipeline (linking Sicily to Algeria while passing through Tunisia), the Greenstream gas pipeline (linking Libya and Italy) and finally the Trans-Adriatic Gas Pipeline (TAP), which links Italy’s Puglia coast to Azerbaijan by way of Albania, Greece and Turkey.[9] Indeed, these infrastructures have become much more critical to Italy’s economy since the Russian invasion of Ukraine in February 2022 and the subsequent diversification efforts away from Russian gas and towards the wider Mediterranean. This in turn will increasingly affect Europe’s energy security, as its supplies of fossil fuels – albeit diminishing thanks to the green transition – is likely to shift in favour of its southern neighbourhood.

[5] This ministry also incorporates the civil protection portfolio previously under the Prime Minister Office.

[6] “Musumeci, Piano del mare al via la prossima settimana”, in *ANSA*, 24 February 2023, https://www.ansa.it/mare/notizie/rubriche/uominiemare/2023/02/24/musumeci-piano-del-mare-al-via-la-prossima-settimana_fd0afe69-81d6-496c-888d-461255cbd96c.html.

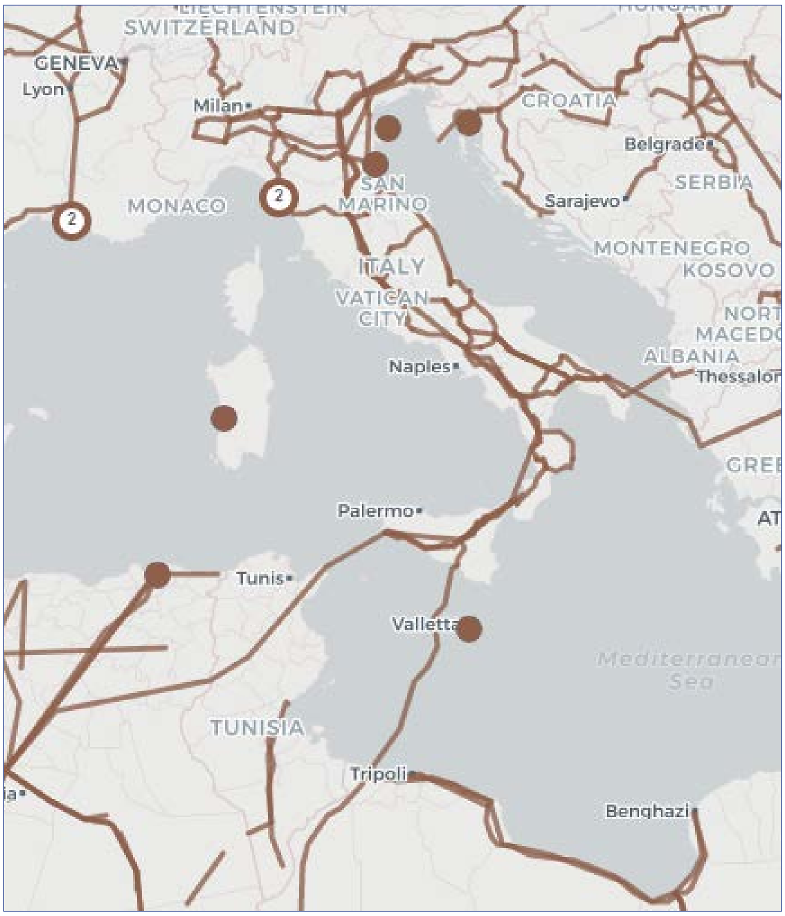
[7] For more on the potential of UUV operations, see chapter 2 of this study.

[8] Gabriele Carrer, “G20 Digitale? L’Italia è l’hub naturale per la connettività sottomarina. Parla Ascani”, in *Formiche*, 5 August 2021, https://formiche.net/?p=1409215.

[9] Global Energy Monitor, *Global Gas Infrastructure Tracker – Tracker Map*, https://globalenergymonitor.org/projects/global-gas-infrastructure-tracker/tracker.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

Figure 3 | Gas pipelines connected with Italy, including four underwater pipelines in Sicily and Southern Italy



Source: Global Energy Monitor, *Global Gas Infrastructure Tracker – Tracker Map*, cit.

Furthermore, as the need for telecommunications bandwidth increases, ongoing development and construction of new cable infrastructure will augment Italy's need to enhance the protection and monitoring of such systems. For instance, Italy will be connected to a 7,100 km submarine cable system known as Medusa, which will link Port Said in Egypt to Lisbon in Portugal at its ends by 2025.[10] Meanwhile, a separate project named BlueMed, will connect a major Data Landing Platform in Genoa with the Red Sea, passing through a data hub in Palermo and tapping into a wider network that touches France, Greece, and Israel as well as other cables in the

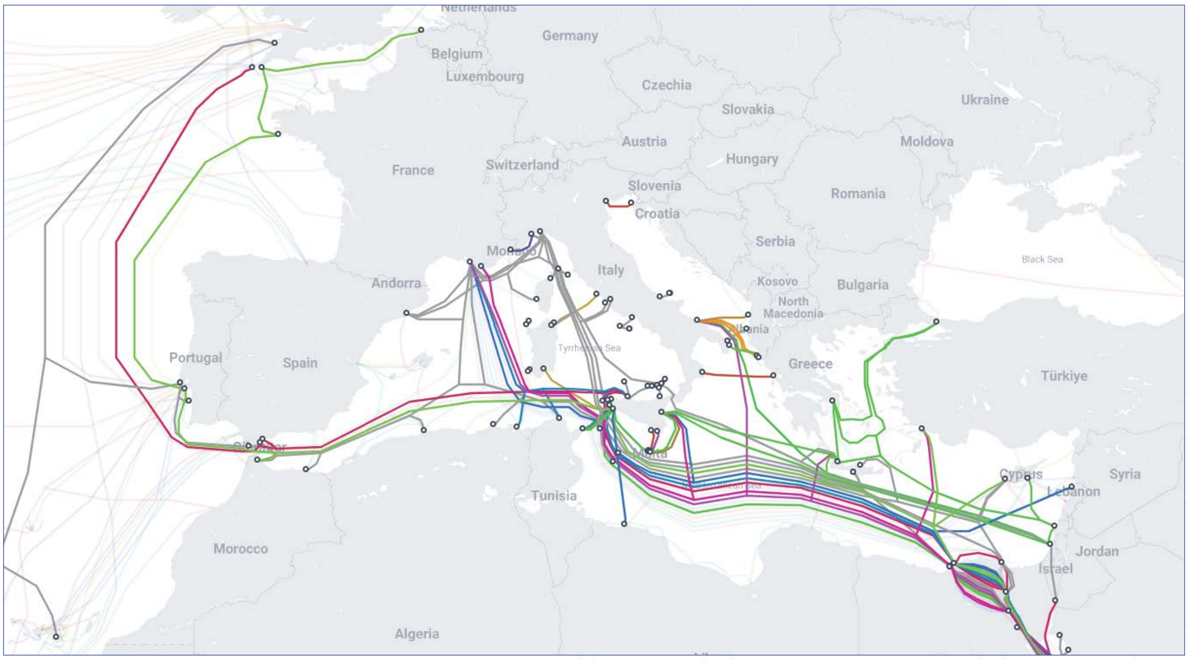
[10] Medusa will be equipped with intelligent monitoring technology in some segments known as Distributed Acoustic Sensing (DAS), an acoustic sensor system which will provide early warning in case of activities potentially posing a threat to the infrastructure. For more information see: European Commission Directorate-General for Neighbourhood and Enlargement Negotiations, *The Medusa Submarine Cable System - Factsheet*, 24 November 2022, https://neighbourhood-enlargement.ec.europa.eu/node/4194_en.

ISSN 2280-6164

Mediterranean.[11] Such developments are in line with global trends, as mentioned by chapter one of this study, whereby more than 90 per cent of data pass through underwater cables.

A unique trait of the underwater domain is indeed the presence of these privately-owned and -operated critical infrastructures away from persistent law enforcement and military surveillance means. In 2022 the Nord Stream 1 and 2 pipeline sabotage has been a wake-up call for most of Italian public opinion and policymakers regarding their vulnerability, although several practitioners – particularly in the Navy[12] – and experts had already pointed to the national security interest to protect such critical infrastructures beyond the country's coastlines. As a result, there is greater awareness in Italy that navies will most probably be required to take a more active role in contributing to the surveillance and protection of these infrastructures.

Figure 4 | Submarine cables connected to Italy



Note: the colour grey indicates future cables.
Source: Submarine Cable Map: https://www.submarinecablemap.com.

Indeed, a shifting approach to this issue can be observed in a Memorandum of Understanding signed in 2022 by the Italian Navy and Sparkle (the Italian company controlled by the TIM Group dealing with underwater cables) to improve the protection of subsea telecommunications infrastructure. The agreement

[11] Italian Ministry of Foreign Affairs, *With BlueMed, Sparkle Creates in Genoa a New Digital Hub for Global Internet Traffic*, 1 March 2023, https://www.esteri.it/en/?p=97536.

[12] The Italian Navy conducted the first Seabed Surveillance operation in the Adriatic region in 2015.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

formalises the will by the Italian Navy (*Marina Militare Italiana* – MMI) and Sparkle to work toward the setting up of "shared operating procedures and the possibility of undertaking joint reconnaissance and monitoring activities of Sparkle's proprietary submarine cables and neighbouring areas". Moreover, the Italian Navy will "provide cartographic support for the seabed of interest as well as assistance in emergency operational situations".[13]

6.3 The underwater operational domain and situational awareness

From a defence perspective, the underwater dimension, spanning from just below the surface to the seabed, is now seen by the MMI as the fifth physical operational domain, beside air, land, maritime, and space.[14] This view is rooted in the peculiarities of the underwater environment, where communication solutions that work above the surface and up into space are severely limited, altered or denied, by the physical constraints inherent to operating inside a body of water, concerning visibility and limited data transfer capacity. The MMI recognises that communicating and operating underwater, especially on the seabed, require a distinct set of technologies, capabilities and doctrines that are in many cases fundamentally different from those that apply to naval combat and other physical domains. In turn, it is argued, mastery of the naval domain does not guarantee control of the deep water or seabed environments. The Italian navy sees underwater warfare as comprising ASW, mine warfare, and seabed warfare,[15] and is keen to lay the foundations for a doctrine review at both the national and NATO levels.

In particular, the underwater environment makes the ability to communicate with submarines and control uncrewed assets operating at depth extremely challenging.[16] Therefore, the MMI believes operating underwater requires a new doctrinal approach, as well as different skills and technological solutions from those used in surface operations, especially considering that the use of UUVs has pushed the boundaries in terms of how deep navies as well as private actors can operate.[17]

According to the MMI, the first necessary step is the pursuit of an adequate underwater situational awareness, a concept similar to those applied to the other operational domains but more difficult to implement due to the aforementioned physical and technological constraints. This could be developed by creating an underwater network made up of interoperable nodes communicating with each

[13] Telecom Italia Sparkle, *Italian Navy and Sparkle Signed Memorandum of Understanding for the Protection of Subsea Telecommunication Cables*, 12 July 2022, https://www.tisparkle.com/media/press-release/italian-navy-and-sparkle-signed-memorandum-understanding-protection-subsea; Chiara Rossi, "Ecco come Sparkle e Marina militare proteggeranno i cavi sottomarini", in *Start Magazine*, 12 July 2022, https://www.startmag.it/?p=199496.

[14] Interview, 15 March 2023.

[15] Ibid.

[16] For more on the challenges to military underwater operations, see chapter 2 of this study.

[17] Interview, 15 March 2023.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

other, including assets operated by civilian operators of seabed infrastructures, to analyse different signatures into a more persistent picture.[18] Such a long-term endeavour for the Mediterranean basin would require a high level of synergy between military and civilian actors as well as law enforcement agencies.

6.4 The national innovation hub for the underwater domain

The presence of non-military actors operating in the underwater domain means that, as is the case generally for EDTs, private and civilian entities hold an increasingly important position when it comes to technological innovation.[19] In the Italian context, Saipem provides a fitting example, thanks to its FlatFish AUV, which is capable of autonomously performing complex inspections of subsea assets thanks to AI.[20] Indeed, FlatFish was designed to also be operated while being based permanently underwater at depths of over 3,000 metres thanks to a "flying-hanging garage", installed on the bottom of the sea, for recharging batteries and configuration through the use of different skids and payloads.[21]

Due to the presence of a number of civilian, military, and industrial structures, the city of La Spezia in northern Italy is becoming a veritable hub for the development of technological and operational solutions linked with the underwater domain. It is concurrently home to a number of companies working on underwater technology, as well as the NATO CMRE and the Italian Navy's Centre for Naval Experimentation and Support (*Centro di supporto e sperimentazione navale* – CSSN) and Divers and Special Forces Command (*Comando Raggruppamento Subacquei e Incursori Teseo Tesei* – COMSUBIN). Crucially, La Spezia is set to host soon the new National Underwater Hub (*Polo nazionale della dimensione subacquea* – PNS), based within by the navy's existing test centre in the city.

As of May 2023, the Hub's governance is still in the making, while its first yearly budget amounts to 2 million euro. It is meant to be a catalyst and an accelerator for technological research and development related to the underwater domain. As such, it aims to become a forum where universities, research centres, start-ups, small and medium-sized enterprises, large companies, the navy and other institutional stakeholders work together to create favourable conditions for innovation, the creation of know-how, and the development of technologies. It will not have production capacities since it is not directly linked to any procurement programme: it will rather support basic and applied research which is going to benefit the national technological and industrial base related to the underwater

18 Ibid.

19 Interview, 3 March 2023.

20 Saipem, *Flatfish*, April 2023, https://www.saipem.com/sites/default/files/2023-04/Flatfish.pdf; Saipem, *Saipem Subsea Drone for Inspection of Shell and Petrobras Fields in Brazil*, 24 May 2022, https://www.saipem.com/en/media/press-releases/2022-05-24/saipem-subsea-drone-inspection-shell-and-petrobras-fields-brazil.

21 Pam Boschee, "Saipem, Shell Work to Advance Subsea Autonomous Vehicle", in *The Way Ahead*, 29 January 2019, https://jpt.spe.org/saipem-shell-work-advance-subsea-autonomous-vehicle.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

domain through a wider innovation process. Another important goal is to provide a forum for all concerned players in the military, civilian, and industrial fields and identify technology trends, priorities and set a roadmap. Ultimately, the Hub's overarching purpose will be to create synergies in terms of research and development in order to enhance the Italian industry's competitiveness in the international markets.[22]

6.5 New Italian submarines and the teaming with uncrewed capabilities

The renewed Italian approach to the underwater domain builds upon a strong tradition in terms of submarines and counter-mines capabilities.[23] For a number of years, Italy has maintained a fleet of eight conventional submarines. Currently, the units in service belong to two separate types: the *Sauro* and *Todaro* classes, all built by the Italian shipbuilding company Fincantieri. The *Sauro* class, an Italian design originating in the Cold War, is composed by four boats. These submarines are approaching obsolescence, especially the two older units, having undergone a major update already two decades ago.[24] The other four *Todaro*-class submarines (also known as Type U212A) all result from a cooperative programme involving Italy and Germany, with the first two units launched in the first decade of the 2000s. The U212A represented a leap forward in terms of the capabilities it grants the MMI, including submerged endurance, AIP and extremely low acoustic signature, but also because of the technical knowledge it has allowed the Italian industry to gain over the years.

Building on an already solid basis, Italian ambitions and priorities in the underwater domain have led to the decision to pursue the next procurement programme on a national basis, by realising the U212 NFS.[25] The MoD had initially procured two boats, which will be delivered to the Navy by 2029 for a total of 1.35 million euro, with an option for further two units in the following years by 2031.[26] The construction of the third submarine was approved by the parliament in May 2023.[27] This class will build on its predecessor, but it will feature a number of completely new capabilities for the Italian navy. Firstly, the MoD has set out plans to fit these submarines with long-range deep strike cruise missiles – a novelty for Italy's submarine fleet that has strategic implication for its future roles.[28] Secondly, a

[22] Interview, 2 May 2023; Interview, 4 May 2023.

[23] Interview, 15 March 2023.

[24] SeaForces.org: *Sauro Class Submarine*, https://www.seaforces.org/marint/Italian-Navy/Submarine/Sauro-class.htm.

[25] For more details on the industrial context surrounding the U212 NFS programme, see chapter 7 of this study.

[26] Organisation for Joint Armament Cooperation (OCCAR) website: *U212 NFS*, https://www.occar.int/programmes/u212-nfs; Giovanni Martinelli, "Sottomarini Fincantieri, tutto sul nuovo contratto per la Marina", in *Start Magazine*, 28 December 2022, https://www.startmag.it/?p=216891.

[27] "Fincantieri Will Build the 3rd U212 NFS Submarine for Italian Navy", in *Naval News*, 31 May 2023, https://www.navalnews.com/?p=45470.

[28] For more on the MM's plans for naval combat systems, including those related to submarines,

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

new, Italian-designed and -made lithium-ion based battery system will power the submarines' AIP propulsion system, granting it even longer endurance and saving maintenance costs.[29] The impressive endurance of the Todaro-class submarines has already given Italy the ability to operate covertly at much greater distances from home ports than ever before.

As mentioned before, the Italian navy sees underwater warfare as encompassing ASW, mine warfare, and seabed warfare.[30] In that regard, one of its main building blocks – considering the importance of uncrewed vehicles in pushing the boundaries of what is possible in this domain – will be MUM-T driven by advanced integration between crewed and uncrewed assets.[31] Indeed, the MMI has published in 2021 an important document outlining its vision for an integrated combat system for its navy, titled "Future Combat Naval System 2035 in Multi-domain Operations" (FCNS 2035), which also looks at the underwater domain.[32]

One of the main goals for the navy, according to FCNS 2035, is to develop the means to operate persistently and without depth limitations (with a view to protecting critical infrastructure) thanks to a fleet of autonomous vehicles. Accordingly, the document continues, platforms including submarines should evolve into "strategic hubs" in order to generate the necessary critical mass and effects where required, including by launching and recovering UUVs and AUVs.[33] At time of writing, the MMI is already operating a number of AUVs, including the HUGIN 1000 (produced by Kongsberg and capable of reaching a depth of 3,000 metres) and REMUS 100 and 300, and is considering future capabilities taking into account the experience of the sea demonstration in the context of the OCEAN2020 project.[34]

Despite existing capabilities and the will to work towards a high-degree of integration among uncrewed vehicles and between uncrewed and crewed platforms, it is clear that more investment – combining the efforts and strengths of both primes and SMEs – is needed in order to research, develop and test solutions in this field and keep up with the evolving technological state of the art.

see IAI's 2023 study: Elio Calcagno and Alessandro Marrone, "Italy", in Alessandro Marrone and Elio Calcagno (eds), "Naval Combat Systems: Developments and Challenges", in *Documenti IAI*, No. 23|01 (January 2023), p. 53-64, https://www.iai.it/en/node/16476.

[29] OCCAR website: *U212 NFS*, cit. For more on the advantages of lithium-ion battery systems as compared to traditional lead-acid-based systems, see: Thyssenkrupp Marine Systems, *The Submarine Revolution: Lithium-Ion Battery System for a Better Performance*, 15 October 2019, https://www.thyssenkrupp-marinesystems.com/en/teaser/the-submarine-revolution--lithium-ion-battery-system-for-a-better-performance.

[30] Interview, 15 March 2023.

[31] Ibid.

[32] Elio Calcagno and Alessandro Marrone, "Italy", cit., p. 60.

[33] Italian Navy, *Il Future Combat Naval System 2035 nelle operazioni multi-dominio*, 2021, https://www.marina.difesa.it/media-cultura/Notiziario-online/Documents/Il%20Future%20Combat%20Naval%20System%202035.pdf.

[34] Elio Calcagno and Alessandro Marrone, "Italy", cit., p. 61-62.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

7. Italy's underwater technological and industrial capabilities

by Michele Cosentino[1]

The Italian defence and shipbuilding industry is experiencing important developments in terms of underwater technologies. The design and construction of the U212 NFS currently ongoing for the Italian Navy can be assessed as a real leap forward for the conceptual and technological evolution of several Italian companies involved in the underwater domain. Such evolution has paved the way for the relaunch of an Italian underwater industrial cluster, which includes large companies and several SMEs. Its output, mainly aimed at satisfying the Italian Navy's requirements, has remarkable applications to civilian tasks such as, *inter alia*, search and recovery of submerged objects, environmental assessment, seabed survey for commercial exploitation. Moreover, in some cases, technologies and systems conceived for the civilian market, notably in the context of the offshore oil & gas industry, are being exploited for or adapted to underwater military applications. The same is true also for UUVs, and their associated support systems (including launch and recovery and command and control) used for underwater military operations, these being easily employed also for civilian tasks. In short, as in other advanced DTIBs, Italy enjoys a continuous cross-fertilisation in the development, production, and use of military and civilian underwater systems.[2]

A survey of the Italian technological and industrial capabilities focused on the military underwater domain has focus on four broad and interlinked areas:

1. submarines, intended as a system of systems comprising all on-board communications, weapons and combat management systems (CMS) conceived and designed for underwater operations and engagements with enemy boats;
2. UUVs and their associated support systems;
3. systems and sensors mainly designed for ISR operations;
4. command and control of an integrated underwater network able to be part of a multidomain architecture for joint operations.

A significant number of Italian large companies and SMEs are involved alongside several academic institutions at various levels in research and technology efforts aimed at consolidating and gradually enhancing the capabilities of the Italian underwater industrial cluster.

At the national level, three institutions coordinate industrial efforts: the Taranto-based Submarine Experimentation Centre (*Centro Sperimentazioni Sommergibili*) and the La Spezia-based CSSN, the former subordinated to the Submarine

[1] Michele Cosentino is Rear Admiral (retired) of the Italian Navy. He graduated from the US Naval Academy in 1978 and has served on submarines and surface ships. He was posted at NATO Headquarters in Brussels and at OCCAR in Bonn. Since 1987 he has been a regular contributor to naval magazines in Italy and abroad.

[2] Interview, 15 February 2023.

© 2023 IAI ISSN 2280-6164 DOCUMENTI IAI 23 | 13 - JUNE 2023

Department of the Italian Navy Staff and the latter under the Italian Navy Logistic Command. The third and larger player in this field is the Secretariat General of Defence/National Armaments Directorate (*Segretariato Generale della Difesa/ Direzione Nazionale Armamenti* – SGD/DNA), part of the Italian Ministry of Defence and responsible for the overall military procurement, research and development.

Additionally, a close partnership has been established between the Italian Navy and some relevant international organisations, such as the La Spezia-based CMRE, part of NATO's Science & Technology Organization.[3] La Spezia is becoming a veritable focal point for underwater innovation, with the upcoming institution of a National Underwater Hub, which will aim to leverage civil-military cooperation and support joint efforts from the public and private sectors. By assessing the activities performed in the four large areas mentioned above, this chapter will focus on the most important Italian companies involved in the underwater cluster, including national champions, CoEs, and SMEs that design, develop, and manufacture underwater systems. The chapter will also deal with the fields of the underwater domain in which the Italian industry depends on foreign know-how and suppliers, and the current most important financial investments aimed at improving domestic technological research for an industrial production of underwater systems.

7.1 The U212 NFS programme: The industrial context

In the 1990s, after the procurement of the eight *Sauro*-class submarines (four batches of two boats each, all equipped mainly with Italian-produced systems), the Navy decided to turn to foreign partners to meet its requirements for modern submarines, thus paving the way for an effective and fruitful collaboration with Germany.

The successful experience gained by Fincantieri from the cooperation between Italy and Germany in the context of the U212A programme, which lead to state-of-the-art AIP attack submarines, has been key in allowing the company to achieve the full technical responsibility for the U212 NFS successor programme. Unlike in the U212A, Fincantieri plays the role of Design Authority for the design of the U212 NFS, so the company can manage autonomously any design changes requested by the Italian Navy during its consolidation. Intellectual property of Foreground Information related to the U212 NFS programme now belongs to Fincantieri and is disciplined within the contract managed by OCCAR (*Organisation Conjointe de Coopération en matière d'Armement*), while the use of Background Information is ruled by an agreement between Fincantieri and the German company TKMS. All this means that Fincantieri has now regained its role as the Italian national champion for the construction of modern submarines, an achievement that would

[3] See NATO CMRE website: https://www.cmre.nato.int. Researches performed by CRME are mainly related to littoral ISR, autonomous surveillance, port and ship protection, maritime situational awareness, environmental knowledge and operational effectiveness, active sonar risk and mitigation.

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

enable the company also to compete in the export market of large and compact submarines.[4]

The U212 NFS is a pivotal programme for Italy, in that it will lead not only to the production of four submarines, but also to the construction of a simulation system for training purposes, the potential development of future underwater technologies, and the provision of in-service support for ten years for the resulting units. The programme involves many Italian and foreign large companies and SMEs and is coordinated by the Rome-based U212 NFS Programme Division of OCCAR.[5] The U212 NFS programme is intended to result in a collaboration between industrial actors as well as universities and can be characterised as a game-changer in the Italian underwater domain. It has capitalised on the experiences of the U212A programme and can build upon the cutting-edge technology that its predecessor produced.

Given that the U212 NFS programme represents a significant leap forward for the Italian industry in terms of ambition, the industrial base is gearing toward a larger portion of the finished submarine than in the older U212A. As in the past, Fincantieri is responsible for the construction of a significant portion of the pressure hull and its casing, the aft and fore planes, the propeller, and the assembly of the forward hull body (by assembling components such torpedo tubes, water ram and weapons handling system manufactured abroad). Additionally, this time Fincantieri performs the role of system integrator for the physical and functional integration of all systems and subsystems – produced in Italy or abroad.

The other Italian industrial champion related to underwater domain is Leonardo, which has developed a new CMS for the U212 NFS, commercially known as Athena Mk.2/U and derived from existing CMSs used on Italian Navy major surface combatant ship. For the U212 NFS submarines Leonardo also produces the Black Shark Advanced (BSA) heavyweight torpedoes and torpedo countermeasures systems.

Another relevant Italian player in the U212 NFS programme is Elettronica, which provides advanced solutions for radar electronic support measures (R-ESM), communication electronic support measures (C-ESM) and early warning functions. It is worth mentioning that all information gathered by Elettronica-manufactured Electronic Warfare sensors are processed through an Electronic Warfare Management Unit and integrated with the U212 NFS CMS.[6] Other Italian companies involved in the U212 NFS are producing several systems and subsystems vital for the platform. For instance, FAAM-FiB-P4F is producing lithium-ion batteries and their Battery Management Systems (a real innovation for Italian submarines), while AvioAero is working on the steering system for the X-shaped aft planes

4 Interview, 9 February 2023.

5 OCCAR website: *U212 NFS*, https://www.occar.int/programmes/u212-nfs.

6 Elettronica is also involved in the life extension programme for the *Sauro*-class Batch 4 submarines.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

and fore planes. Calzoni, a Bologna-based L3Harris-owned company with world-leading capabilities in terms of universal modular masts (UMM),[7] which it supplies also to the US *Virginia*-class SSNs and *Ohio*-class SSGNs, as well as electrically powered masts and uncrewed surface vessels. The U212 NFS programme provides an opportunity also for a number Italian SMEs which play a role in the underwater domain. This is the case for Next Tech, a Fincantieri-owned company which has developed and manufactured the Integrated Platform Management System (IPMS)[8] for GEM Elettronica working on the radar and for Rochem-Marine concerning the production of fresh water through inverse osmosis systems.

7.2 The Italian industrial and technological landscape

The Italian DTIB includes a wide array of prime contractors and SMEs that supply the Italian armed forces and UCI operators with innovative solutions, including in the underwater domain. As prime contractor of submarines being built at the Muggiano shipyard (La Spezia), Fincantieri manages all the production phases of submarines, including design, suppliers' selection, construction, testing, delivery, trials, and in-service support. The Fincantieri Marine group is one the world's leading shipbuilders, with operations and subsidiaries spanning multiple countries and revenues in the defence sector totalling 1.6 billion euro.[9] In terms of large, crewed platforms, besides the U212 NFS programme, Fincantieri is proposing the S800, a relatively small submarine characterised by a diesel-electric and AIP system, able to carry a team of eight SOF operators and ten torpedoes.[10]

With revenues amounting to 14.7 billion euro in 2022, Leonardo is a leading player in the defence field, offering a wide array of naval combat systems. As far as the underwater domain is concerned, Leonardo has developed several advanced technologies and products, including heavyweight and light torpedoes, an active/passive sonar for panoramic surveillance and classification of various types of underwater vehicles (Active Towed Array System – ATAS), the Black Snake passive towed sonar, and the Mobile Jammer Target Emulator (MJTE) a countermeasures system capable of generating false targets and thus allowing the launching platform to carry out effective evasive manoeuvres.[11] Leonardo is also responsible for the Combat Management System (CMS) of submarines, and is investing on UUV technology.

[7] Calzoni has become the international champion for UMMs, these being produced for the Virginia-class and SSGN/Ohio-class nuclear submarines in service or being constructed for the US Navy.

[8] Integrated Platform Management Systems manage all systems related to the functioning of the submarine as a platform, including among others propulsion, power generation and distribution, and ventilation.

[9] Fincantieri, *Annual Report 2022*, 5 April 2023, https://www.fincantieri.com/en/investors-relations/financial-statements.

[10] Giovanni Martinelli, "Ecco come sarà il nuovo sottomarino di Fincantieri S800", in *Start Magazine*, 27 February 2023, https://www.startmag.it/?p=223619.

[11] Leonardo Electronics website: *Leonardo's Technologies to Protect the Underwater Domain*, https://electronics.leonardo.com/en/focus-detail/-/detail/technologies-protect-underwater.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

The approach of the Italian Navy to the whole underwater domain has boosted the involvement of several Italian SMEs for conceiving, designing, and manufacturing of underwater platforms and systems which have densely populated the national industrial underwater cluster. Among the medium-size companies of such cluster, it is worth to recall Cabi Cattaneo, established in 1936 and historical manufacturer of wet swimmer delivery vehicles (SDVs) and their associated systems, notably Dry Dock Shelter, for Italian Navy's Special Forces, and DRASS, active since 1927 with the Galeazzi business line and achieving extensive experience in, *inter alia*, crewed underwater technology, midget and compact submarines, and SDVs for special forces. Additionally, DRASS produces a large spectrum of submarine rescue vehicles and their associated launch and recovery systems from surface rescue vessels, including those procured for the Special & Diving Operations-Submarine Rescue Ship (SDO-SuRS), currently being built for the Italian Navy. The experience and knowledge of DRASS in the underwater domain stem from a fruitful cooperation with Saipem, the Italian company specialised in advanced technology and energy management, notably in oil and gas offshore infrastructures and systems. Saipem is also working in several research projects related to the underwater domain, notably robotic systems for seabed operations. Thus, Saipem has developed the Hydrone family of dual-purpose deep-sea ROVs and AUVs, including the FlatFish AUV, able of reaching a depth of 3,000 metres with an endurance of up to 12 hours.[12]

The industrial scenario of Italian companies producing midget submarines includes also M23 S.r.l., a spin-off company from Giunio Santi Engineering Ltd (GSE),[13] which is building two midget submarines for the Qatari Emiri Naval Forces.[14]

Established in 1998, GraalTech is a Genoa-based firm which designs, develops, and builds underwater reconfigurable systems such as the X-300 family of AUVs. Another SME involved in the underwater domain is W-Sense, a deep-tech spinoff company of the Roma-based La Sapienza university specialised in underwater monitoring and communication systems, based on patented technologies that have pioneered the Internet of Underwater Things (IoUT).

Italian SMEs' activities complement efforts undertaken under the aegis of the U212 NFS programme and have been implemented also through the exploitation of a research & development funding mechanism such as the National Plan for Military Research (*Piano nazionale di ricerca militare* – PNRM), managed by the SGD/DNA. As for the underwater domain, there are currently several ongoing PNRM projects,

[12] Saipem website: *Hydrone - Njord Field Development*, https://www.saipem.com/en/projects/hydrone-njord-field-development.

[13] Previously known as Maritalia and having a long tradition of innovation in air independent propulsion systems and unique hull construction.

[14] H.I. Sutton, "Qatar's Navy New Submarine: About M23 SRL", in *Covert Shores*, 16 May 2021, http://www.hisutton.com/M23-Submarines-Italy-Qatar.html.

ISSN 2280-6164

each lasting typically between two and three years, mainly involving SMEs. They broadly relate to three major tracks: Next Generation Submarines, UUVs, integrated underwater surveillance, and command & control systems, all possibly adopted by the Italian Navy during the current and next decades. Besides large companies and SMEs, numerous PNRM underwater-related projects involve a broad network of Italian universities, many of which are coordinated by the Interuniversity Centre of Integrated Systems for the Marine Environment (*Centro interuniversitario di ricerca di sistemi integrati per l'ambiente marino* – ISME). The overall coordination of ISME is provided by the University of Genoa.[15]

7.3 Funding the underwater domain

The Italian MoD is investing in several strands of the underwater domain in accordance with the four macro areas identified above (submarines; UUVs; ISR sensors and systems; command and control). The most significant effort obviously regards the U212 NFS programme, which is expected to cost over 2.6 billion euro, split in two tranches. The programme will be co-funded by the then-Ministry for Economic Development (*Ministero dello Sviluppo economico* – MISE), and the Ministry of Defence as outlined in the 2022-2024 Defence Multiyear Programming Document (*Documento Programmatico Pluriennale* – DPP).[16]

The DPP 2022–2024 includes also about 108 million euro for the procurement of an undisclosed number of Black Shark heavyweight torpedoes and about 2 million euro to update the CMS software of the Todaro-class units. Additionally, the Italian Navy is investing 9 million euro for the procurement of three new deployable UUVs for MCM operations.

7.4 Industrial contributions from abroad

Although the Italian industrial underwater cluster is heavily committed in satisfying many of the Navy's operational requirements, and there is a degree of autonomy relating to a number of technologies concerning to lithium batteries, EW, CMS, IPMS and torpedoes, there are still some capability gaps to fill for which Italy has to rely on foreign know-how and procurement.

These gaps span across the four macro areas identified above and are related mainly to: UUVs deployable from ships and submarines; propulsion and power generation systems; sensors for communication and above-water surveillance; new generation of AIP systems for submarines and UUVs (namely fuel cells

[15] The list of the Italian universities and SMEs involved in PNRM projects and their fields of activity is provided in Annex 1.

[16] In the 2022–2024 DPP, the military technological research activities are grouped into 7 clusters. Those closely related to the underwater domain can be generally grouped into cluster 1 (innovation technologies for ISR and information sharing through advanced command & control systems), cluster 2 (autonomous systems, artificial intelligence, navigation safety and security) and cluster 4 (cyber security and big data analysis).

ISSN 2280-6164

with higher energy density and on-board production of reactants); passive and active sonar suites (including towed array sensors) for speeding-up detection and identification of underwater threats; and enhancement of interoperability and interaction between submarines, UUVs and surface assets through new communication tools. The efforts aiming to build these capabilities are also linked to the implementation of two concepts: underwater situational awareness and the establishment of an 'underwater library' conceptually similar to that existing on surface ships for EW purposes.[17]

Moreover, submarine-launched cruise missiles for deep strike missions are a novel significant gap for the Italian defence industry, given recent news regarding the possible inclusion of the capability in the U212 NFS programme.

Considering the capabilities committed to the U212 NFS programme and thanks to the activities stemming from several PNRM projects, it is possible to state that the Italian industrial underwater cluster is likely able to overcome, although partially, some of the capability gaps identified above, independently and/or through cooperation with other European and international industrial actors.

Finally, a significant boost to enhance the capabilities of the Italian underwater industrial cluster will come from the establishment at La Spezia of the PNS. Controlled by the Italian Navy, the PNS will act also as an accelerator and enabler for the supply chain, by better linking military operational requirements and all industries, universities, and research centres able to provide innovative solutions in the underwater domain.

[17] Interview, 15 February 2023.

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

8. Conclusions

by Alessandro Marrone and Michele Nones[1]

The underwater domain is becoming increasingly congested, competitive and contested. Despite the immensity of the world's seas and oceans, certain areas are congested with a high concentration of pipelines, cables and off-shore energy platforms critical for the world economy and the functioning of modern societies – including in Europe. It is competitive as contrasting national claims on economic exclusive zones make Mediterranean Sea and other basins a field of political and security competition among littoral states. Finally, the underwater domain is contested because technological advancements in terms of submarine and seabed warfare are granting global and regional powers the ability to deploy underwater capabilities – including drones – far beyond their coastlines.

The 2022 sabotage of Nord Stream has been a stark reminder of the congested, competitive and contested features of the underwater domain, particularly in relation to Europe's security and defence. Recent developments in terms of strategy and doctrines taking place in France, Germany, Italy and the UK show that major European countries are taking stock of this reality and adapting their posture accordingly.

Just as naval power, the ability to act in the underwater domain is not built exclusively on military capabilities. Operations above and below the surface certainly rely on warships, submarines, ASW platforms, UUVs and sensor networks, to name only a few of the involved assets. However, underwater capabilities should be conceived as spanning to civilian and/or privately-owned assets, including oceanographic survey and cable laying ships as well as UCI. Furthermore, most of the world's seabed remains unexplored and therefore projecting power in this domain depends not only on a degree of persistent situational awareness, but also on the ability to explore and map the underwater morphology down to even thousands of metres in depth.

Against this backdrop, there are three key, interrelated elements to consider: UCIs, submarines and UUVs.

8.1 Critical infrastructures: a public-private partnership

One of the key aspects of the underwater domain is that, while UCIs are not new, their growing numbers and relevance require that operators and navies exercise a degree of protection and surveillance. Indeed, these infrastructures now represent a sort of neurovascular system of the globalised economy, whose disruption would create serious economic and strategic shocks, particularly to Europe. The

[1] Michele Nones is Vicepresident of IAI.

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

increasing salience of UCIs is due in large part to the relative novelty represented by the extension, number and importance of seabed internet cables and energy pipelines – as well as by the necessity to protect off-shore platforms also from underwater threats.

These assets are mostly owned and/or operated by private and civilian actors, but they are key for national security. Therefore, a new public-private partnership is needed to improve and ensure their resilience and protection, *in primis* by creating a network of early warning sensors to identify threats and enable a timely reaction. Such a partnership should involve a number of private actors, law enforcement agencies, MoDs and other relevant institutions. A network-oriented approach could ensure that, where possible, these infrastructures can turn from an isolated target to an asset that is part of a larger system of systems, themselves becoming a network of sensors contributing to data fusion processes resulting in a shared situational awareness.

Since UCIs often stretch well beyond territorial waters, thorough the high seas and to the coastline of third countries, partnerships should be established also at the regional and international levels. The Mediterranean Sea is a case in point, with an expanding and diverse network of UCIs connecting several littoral states in Europe, Africa and the Middle East. Placed at the centre of the Mediterranean, for both geographical and historical reasons the Italian peninsula is a natural hub in the region, in particular for energy pipelines and increasingly for internet cables. In this context, Italy can and should play a leading role in building regional partnerships to enhance jointly with other players the security of seabed critical infrastructures. Renewed bilateral, north-south and NATO–EU cooperation will be all crucial in this regard.

The physical nature of the underwater environment means that the defender will always be at a disadvantage in terms of UCI protection, as attacks are and will remain difficult to prevent over massive areas. Therefore, a new approach to avoiding that individual attacks cause disproportionate disruption should be pursued. First, through redundancy where applicable, especially with regard to cables. Secondly, it may be useful to borrow and adapt the concept of "responsive space" from the space domain and apply it to the underwater domain. In the context of undersea cables, for instance, a "responsive underwater" concept could entail the ability by operators, in partnership with specialised entities, to quickly deploy cable laying ships where needed in order to restore service. Increasing redundancy and enhancing repair capabilities, both in scope and timeliness, will at the very least limit the disruption potential of sabotage actions. Indeed, it may in some cases act as a deterrent by making the disruption resulting from sabotage modest or short-lasting and therefore, potentially, a less enticing prospect for adversaries.

8.2 Submarines: managing industrial competition and military cooperation

A second key element is the ongoing renaissance of submarines, with increasing demand from both traditional naval powers and mid-sized navies keen to acquire

DOCUMENTI IAI 23 | 13 - JUNE 2023
ISSN 2280-6164

them for the first time. Market opportunities are on the rise from the wider Mediterranean to the Indo-Pacific, while new technologies are being developed ranging from propulsion to connectivity. Furthermore, as argued in this study, submarines are well-placed to act as strategic hub for UUVs. In this context, AIP has changed the role of conventional submarines, as it enables longer missions at extended ranges far from the homeland and partners' ports, thus enhancing their use for missile deep strike for deterrence purposes.

When it comes to new submarines, recent trends show that most countries in Europe that have the necessary capabilities are pursuing national procurement programmes with little-to-no intra-European cooperation – with the notable exception of Germany and Norway. Several capitals consider these platforms and the related operational and technological sovereignty as strategic for national security and defence, and in some cases nurture strong ambitions in terms of exports. As a result, the underwater domain will see more industrial competition among Europeans. This in turn will likely affect bilateral and multilateral relations, as has happened between France and UK in the aftermath of the AUKUS deal and Australia's cancellation of the French submarines' contract. The impact of competition will have to be managed at the political and strategic levels in order to avoid or at least mitigate negative spillover effects in other areas.

Still, the magnitude of the strategic challenges posed by Russia and China, including in the underwater domain, calls for more military and political cooperation within the EU, NATO and broadly speaking the Western world. This kind of cooperation may involve submarines and all other underwater and naval assets necessary to monitor and protect critical infrastructures, *in primis* those serving Europe. Military cooperation is also needed to ensure a Western naval presence from the wider Mediterranean to the Indo-Pacific, by connecting platforms, sensors and infrastructures, and by pooling assets for maritime operations – as is done in the context of international carrier strikes groups. The EU and NATO should work in synergy to mobilise and coordinate operational efforts by their members, also considering the growing overlap of memberships between the two entities in light of Finland's accession to the Alliance and Sweden's process towards it.

8.3 UUVs: European cooperation and a novel approach

A third key element are the recent advancements in the development and use of UUVs, which open new possibilities for underwater and seabed operations by removing the obstacles and limits connected to the survival of humans hundreds or thousands of metres below the surface.

European cooperation is necessary and possible concerning UUVs, particularly regarding autonomous ones, and the related – often emerging and disruptive – technologies. Here Europe cannot afford a fragmentation of investments, for instance regarding technologies such as artificial intelligence, edge and quantum computing, particularly vis-a-vis the huge investments foreseen by China. Several work-strands are going on at national level in this regard, or under EDA,

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

PESCO and EDF aegis, as well as within NATO considering the implementation of DIANA and NATO Innovation Fund (NIF). Synergy, cross-fertilisation between civilian and military efforts, cooperation and pooling of investments should be the guiding principles if the West as a whole wants to build and maintain a sustainable technological edge also in the underwater domain. National initiatives such as the Italian *Polo nazionale della dimensione subacquea* can and should play a meaningful role in this regard. At the same time, NATO's work on standards – particularly on STANAG 4817 – is crucial and should move forward to ensure interoperability among allied assets, which will ideally lead to the ability for crewed assets from one navy to control or receive information from UUVs belonging to another navy in a seamless manner.

Within NATO navies, UUVs are meant to complement rather than replace crewed vehicles, by acting as force multipliers and by enabling new capabilities – for instance at extreme depths, very shallow waters or in particularly dangerous areas. Indeed, drones in underwater operations should not be seen exclusively as potential replacements of crewed assets, but as new assets able to carry on, in the near future, complex and autonomous tasks and operations in synergy with submarines and vessels. Indeed, the former should eventually act as strategic hub to manage swarms of underwater drones. An effective, combined use of crewed and uncrewed capabilities will therefore require a novel approach and a significant doctrinal evolution within the military, with evolving force architectures and doctrines accounting for a degree of command and control capabilities devolved to uncrewed assets.

8.4 The challenges and opportunities of dual-use technology

A common feature of the aforementioned three key elements is dual use technology. Technological innovation in the underwater domain fuels, as in others, the eternal contest between sword and shield by enabling both offensive and defensive operations, and has a strong dual use character. New sensors and communication systems will be used by both UCI operators and navies – although with some degrees of customisation. Artificial intelligence and quantum computing are emerging disruptive technologies across the civil-military continuum, and the bulk of investments on them comes from the civilian world. Yet, for instance, UUVs for ISR purposes are inherently dual-use. When it comes to propulsion and energy generation and storage, moreover, there are a number of spillover opportunities between military and multiple civilian sectors, ranging from hydrogen fuel cells to lithium-ion batteries.

Such a situation presents a set of both challenges and opportunities to the armed forces. One of the challenges will be for the military operators to master technologies that are and will be primarily developed by the civilian sector. Conversely, there is a concrete opportunity to leverage the investments made by companies beyond the perimeter of military budgets. In any case, ministries of defence will have to reach out to a broad range of stakeholders to ensure the required levels of synergy in investments in order to make sure the resulting technologies can satisfy

© 2023 IAI
ISSN 2280-6164
DOCUMENTI IAI 23 | 13 - JUNE 2023

© 2023 IAI

ISSN 2280-6164

their operational requirements. Again, initiatives like the *Polo nazionale della dimensione subaquea* have the chance to also serve this goal.

8.5 Six key points for Italy

Against this backdrop, the following six points for Italy are key:

1. More attention to the underwater domain within a coherent MoD posture
2. The NFS as catalyst for innovation
3. The diversification of submarine markets and the opportunity of smaller platforms
4. A leading role and a pooling of investments on UUVs and AI
5. A renewed approach to UCI surveillance and protection
6. An effective *Polo nazionale della dimensione subacquea*

First, the underwater domain deserves more attention and investments by Rome than in the past, while the navy and the whole MoD should move forward with the related doctrinal and capability development within a coherent and synergic posture. Italy should take into account the territorialisation process under way in the Mediterranean and beyond, while also bearing in mind the watershed moment represented by the Russian invasion of Ukraine and the NATO shift back towards high-intensity conflict scenarios against a peer competitor. This has significant implications in terms of anti-submarine, mine and seabed warfare in order to achieve sea control at least in the Mediterranean basin but also to penetrate enemy defences and sea denial capabilities in a conventional conflict.

Second, Italian military and industrial actors will have to work closely together to make the U212 NFS programme a success, by tackling the challenges and grasping the opportunities of greater operational and technological sovereignty on the new platforms. In fact, the NFS can and should become a catalyst for innovation by both prime contractors and the whole supply chain, including SMEs. The bow, propulsion system and power generation and storage (i.e. hydrogen fuel cells and lithium-ion batteries) stand out as some of the top priorities in this regard. Noticeably, the programme will result not only in the platform, but also in an array of related, promising technologies and capacities such as an underwater simulation system. Due to the specificities of this domain and the features of defence procurement, this is a long-term effort which requires multi-year continuity of investments and the ability to adapt the design and the related systems frequently if necessary, taking into account a fast-paced competitive environment.

Third, as mentioned before, the international markets, including both well-established naval powers and mid-sized navies, are witnessing a renewed interest for submarines. Indeed, a number of countries are working toward building up (or in the Italian case re-establishing) advanced domestic industrial capabilities, with a clear ambition to enter the export market. A proliferation of potential customers, with often different and specific requirements, will likely make the markets more dynamic and diversified, granting Italian companies an opportunity to carve out a competitive portfolio. In this regard, smaller submarines can represent a significant niche since they are ideal for shallow water operations and require a reduced crew and more limited investments by mid-sized navies. In any case, given the strategic character of these capabilities, public-private coordination is necessary to effectively support an Italian projection into global markets, ranging from the wider Mediterranean to the Indo-Pacific. In particular, Italy should pursue government-to-government agreements in order to place exports within a broader partnership encompassing training, logistic support and upgrade activities.

Fourth, Italy can and should play a leading role in the development and integration of UUVs. This will require a whole-of-government approach and a broad cooperation effort encompassing the military, the shipbuilding and defence industries, and civilian companies including Sparkle, Prysmian, Saipem and Eni. Pooling investments and channelling research and development efforts toward common and coherent goals would serve both the security of UCIs and the military requirements. Considering the aforementioned challenges of underwater communication and navigation and the subsequent need for greater autonomy, AI is a top priority for cooperation and joint investments, *in primis* between Fincantieri and Leonardo. Managing drone swarms presents further challenges in terms of automation, AI and adequate communications, as well as command and control networks which can be tackled only by channelling efforts and pooling investments in a way that also finds common ground between private capital and military operational requirements. Moreover, developing national – or European – solutions for the underwater domain would enhance security of supply and make sure AI and autonomous drones are developed in line with European values from a political and ethical perspective.

Fifth, Italy should renew the surveillance and protection of UCIs in the Mediterranean basin to mitigate the risk of a Nord Stream-style sabotage. The extension and numbers of these infrastructures require a new approach, whereby drones and sensors can and should compensate for the scarcity of crewed assets vis-à-vis the wide area to cover. The timely exchange of information among different assets and the rapid deployment of UUVs – also by other, larger UUVs acting as mother ships – will be key. In the Mediterranean basin, the aim should be the creation of an integrated underwater network, made up of nodes in communication among each other thanks to a mature, standardised technological solution. Such solution should consider the requirement of interoperability, feed from a number of sources including assets operated by civilian UCI operators, and putting different signatures into a more persistent picture. Achieving this will require an even closer and timely dialogue among users and developers of technologies. Within Italian territorial waters, such a new approach should go hand in hand with the establishment of an authority for the underwater traffic to streamline and synergise the contribution of various branches of Italian national and local institutions. Beyond territorial waters, the aforementioned cooperation with littoral states will be key.

Last but not least, the *Polo nazionale della dimensione subaquea* is a novel and complex endeavour which should be crafted properly. It should involve all relevant

DOCUMENTI IAI 23 | 13 - JUNE 2023
ISSN 2280-6164

actors with special attention to innovative SMEs and start-ups have a clear dual-use character, and rely on an effective governance to act as catalyst and accelerator of national research and technology efforts. It should also smoothly plug into relevant EU and NATO frameworks, including PESCO and EDF, DIANA and NIF, in order to foster technological cooperation at European and transatlantic levels. The geographic and functional proximity with NATO CMRE – which is already playing a crucial role in this field thanks to programmes relating to the implementation of concepts such as collaborative teams of UUVs, autonomous capabilities in ASW and acoustic sonar barriers – should be turned into a close partnership. The Polo should be established in a timely manner and managed with a long-term perspective, by ensuring stable commitment and investments over the years in order to achieve meaningful results.

Updated 22 June 2023

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

Annex 1. SMEs and Italian universities participating in PNRM projects related to the underwater domain

Company and location	**Field of activities**
W-Sense (Rome)	Deep-tech spinoff company of Sapienza University, specialised in underwater monitoring and communication systems.
Graal Tech (Genoa)	Development and production of underwater reconfigurable systems.
Wireless & More (Padua)	Spin-off company of the University of Padua, developing solutions for underwater acoustic and optical wireless communication.
Technav Systems (Leghorn)	Development of fixed and mobile underwater sensor and systems, processing of acoustic signals, analysis and integration of underwater systems and their associated engineering logistic.
Dune Ltd (Rome)	Development of sonar systems for underwater surveillance and discovery, research and tracking of targets, including multi-processor architectures and high-rate data processing.
Power4future, P4F (Genoa)	Joint venture between Fincantieri SI and Faist Group, production of ionium-lithium batteries and battery management systems.
MDM Team (Florence)	Spin-off company of Florence University, design and prototyping of complex mechatronics systems, including UUVs.
SIEL (La Spezia & Turin)	Production of Uncrewed Surface Vessels, autopilot systems, telemetry, and remote control systems, underwater navigation and communication systems.
Carbon Dream (Florence)	Production of carbon-fibre components.
FlySight Ltd. (Roma)	Designing and development of software for C4ISTAR systems.
Optosmart Ltd. (Naples)	Spin-off company from Sannio and Naples Universities and CNR, development of monitoring systems based on fibre-optic sensors.
KairoSpace (Foggia)	Design and development of hybrid multi-functional composites, algorithms of evolutionary computation and hi-tech devices design.
Engineering ingegneria informatica s.r.l. (Rome)	Part of Engineering Group, development of digital media and communication systems.
ARCO Fuel Cells (Bologna)	Development and production of Polymer Membrane Fuel Cells and ionium-lithium batteries.
EdgeLab Ltd. (La Spezia)	Design, development, and production of UUVs, underwater robotics, sea technologies and sensors.
Next Geosolutions, NextGeo (Naples)	Provider of marine geoscience and offshore construction support services for offshore oil and gas industry.
TELSY (Rome, Milan, Naples, Turin)	TIM-controlled company specialised in encryption/decryption and cyber security.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

QTI Ltd. (Florence)	Development and production of Quantum Key Distribution (QKD) architectures.
T4i, Technology for Propulsion and Innovation s.r.l. (Padua)	Production of electric propulsion systems, cold gas systems and chemical propulsion systems.
Breton (Padua)	Research, development, and industrialisation of new materials for electrochemical devices.
Dallara (Parma)	Composite materials.

Current members of the ISME (Interuniversity Centre of Integrated Systems for the Marine Environment) are the universities of Genoa, Salento, Pisa, Politecnico delle Marche, Cassino and Southern Lazio, Bologna, Rome La Sapienza, Calabria, Florence. The researchers of ISME are active in oceanic engineering and marine technology research focusing mainly on the following topics: marine robotics, underwater acoustics, communication and networking, renewable energies, modelling, and simulation.

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

Acronyms

A2/AD	Anti-access/area denial
ADD	Agency for Defence Development
ADF	Australian Defence Force
AI	Artificial intelligence
AIP	Air-independent power
ASI	Automatic Identification System
ATAS	Active Towed Array System
ATT	Anti-Torpedo Torpedo (project)
AUV	Autonomous underwater vehicle
ASW	Anti-submarine warfare
BSA	Black Shark Advanced
C-ESM	Communication electronic support measures
CHOF	Capacité Hydrographique et Océanographique Future
CMRE	Centre for Maritime Research and Experimentation
CMS	Combat management system
CoE CSW	Centre of Excellence for Operations in Confined and Shallow Waters
COMSUBIN	Comando Raggruppamento Subacquei e Incursori Teseo Tesei
CRIMARIO	Critical Maritime Routes Indo-Pacific (project)
CSIP	Critical Seabed Infrastructure Protection (project)
CSSN	Centro di supporto e sperimentazione navale
DIVEPACK	Deployable Modular Underwater Intervention Capability (project)
DPP	Documento Programmatico Pluriennale
DSME	Daewoo Shipbuilding & Marine Engineering
DTIB	Defence technological and industrial base
EDA	European Defence Agency
EDF	European Defence Fund
EDT	Emerging disruptive technology
EEZ	Exclusive economic zone
ELF	Extremely low frequency
ESNA	Escadrille des Sous-marines nucléaires d’attaque
ESNLE	Escadrille des Sous-marines lanceurs d’engins
EU	European Union
EUMSS	EU Maritime Security Strategy
EW	Electronic warfare
FNCS	Future Combat Naval System
FSM	Forces sous-marines

ISSN 2280-6164

GPS	Global Positioning System
GUGI	Glavnoye upravlenie glubokovodnikh issledovanii
HARMSPRO	Harbour and Maritime Surveillance and Protection (project)
IoUT	Internet of Underwater Things
IPMS	Integrated Platform Management System
ISME	Interuniversity Centre of Integrated Systems for the Marine Environment
ISR	Intelligence, surveillance and reconnaissance
JMSDF	Japanese Maritime Self-Defence Force
LUUV	Large-sized uncrewed underwater vehicle
MARSUR	Maritime Surveillance (project)
MAS MCM	Maritime (Semi-) Autonomous Systems for Mine Countermeasures (project)
MCM	Mine countermeasure
MHI	Mitsubishi Heavy Industries
MISE	Ministero dello Sviluppo economico
MIW	Mine warfare
MJTE	Mobile Jammer Target Emulator
MMI	Marina Militare Italiana
MN	Marine Nationale
MoD	Ministry of Defence
MROS	Multi-Role Ocean Surveillance Ship
MUM-T	Manned-unmanned teaming
MUS	Maritime Unmanned Systems
MUSAS	Maritime Unmanned Anti-Submarine System (project)
NATO	North Atlantic Treaty Organization
NFS	Near Future Submarine
NIF	NATO Innovation Fund
OCCAR	Organisation Conjointe de Coopération en matière d'Armement
PADR	Preparatory Action on Defence Research
PESCO	Permanent Structured Cooperation
PLAN	People's Liberation Army Navy
PNRM	Piano nazionale di ricerca militare
PNS	Polo nazionale della dimensione subacquea
R&D	Research and development
RAN	Royal Australian Navy
REA	Rapid environmental assessment
REPMUS	Robotic Experimentation and Prototyping with Maritime Unmanned Systems
R-ESM	Radar electronic support measures

ISSN 2280-6164

RMS	Remote Mine-hunting System
RN	UK Royal Navy
ROKN	Republic of Korea Navy
ROUV	Remotely operated underwater vehicle
SAR	Search and recovery
SDO-SuRS	Special & Diving Operations-Submarine Rescue Ship
SDW	Swimmer delivery vehicle
SGD/DNA	Segretariato Generale della Difesa/Direzione Nazionale Armamenti
SLOC	Sea line of communication
SM	Svenska Marinen
SME	small and medium-sized enterprises
SOF	Special operation force
SSBN	Nuclear ballistic missile submarine
SSK	Conventional propulsion attack submarine
SSN	Nuclear-powered attack submarine
SSN(R)	Submersible Ship Nuclear (Replacement)
SSUSV	Semi-submersible unmanned surface vessel
STANAG	NATO Standardization Agreement
STO	NATO Science and Technology Organization
TAP	Trans-Adriatic Gas Pipeline
TKMS	ThyssenKrupp Marine Systems
UCI	Underwater critical infrastructure
UK	United Kingdom
UMM	Universal modular mast
US	United States
UUV	Uncrewed underwater vehicle
UUVRON	Unmanned Undersea Vehicles Squadron
VLF	Very low frequency
VMF	Voyenno-morskoy flot
XLAUV	Extra-large autonomous underwater vehicle
XLUUV	Extra-large uncrewed underwater vehicle

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

DOCUMENTI IAI 23 | 13 - JUNE 2023 ISSN 2280-6164

Istituto Affari Internazionali (IAI)
The Istituto Affari Internazionali (IAI) is a private, independent non-profit think tank, founded in 1965 on the initiative of Altiero Spinelli. IAI seeks to promote awareness of international politics and to contribute to the advancement of European integration and multilateral cooperation. Its focus embraces topics of strategic relevance such as European integration, security and defence, international economics and global governance, energy, climate and Italian foreign policy; as well as the dynamics of cooperation and conflict in key geographical regions such as the Mediterranean and Middle East, Asia, Eurasia, Africa and the Americas. IAI publishes an English-language quarterly (*The International Spectator*), an online webzine (*AffarInternazionali*), two book series (*Global Politics and Security* and *IAI Research Studies*) and some papers' series related to IAI research projects (*Documenti IAI*, *IAI Papers*, etc.).

Via dei Montecatini, 17 - I-00186 Rome, Italy
T +39 06 6976831
iai@iai.it
www.iai.it

Latest DOCUMENTI IAI

Director: Alessandro Marrone (a.marrone@iai.it)

23 | 13	Elio Calcagno and Alessandro Marrone (eds), *The Underwater Environment and Europe's Defence and Security*
23 | 12	Federico Castiglioni, *A Stronger Italian-German Partnership: Closer Cooperation in Time of Energy Crisis*
23 | 11	Akram Ezzamouri and Miriam Zenobio, *EU–Tunisia Relations: Unpacking the Conundrum*
23 | 10	Matteo Bonomi, Luisa Chiodi and Irene Rusconi, *New Visions for the Western Balkans: EU Accession and Regional Security*
23 | 09	Leo Goretti, *La sicurezza italiana e la guerra contro l'Ucraina: i punti di vista degli esperti*
23 | 08	Manuel Herrera, *The War in Ukraine and the Future of Non-proliferation and Arms Control in the European Continent*
23 | 07	Dario Cristiani, *Europe's Evolving Order and the War in Ukraine*
23 | 06	Ottavia Credi, Giancarlo La Rocca e Alessandro Marrone, *Il dominio spaziale e la minaccia cyber*
23 | 05	Alessandro Marrone e Elio Calcagno, *Sistemi di combattimento navali: sviluppi e sfide*
23 | 04	Nicolò Fasola et al., *Space – Exploring NATO's Final Frontier*