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From the Sea and Beyond

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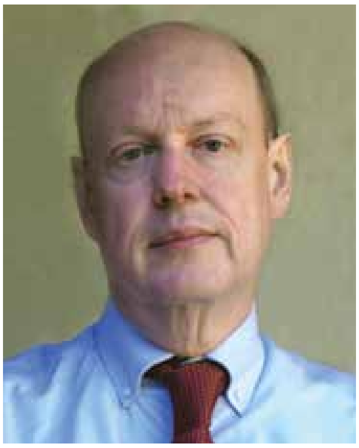

This combined edition of European Security & Defence (ESD) and Maritime Defence Monitor (MDM) has been published to coincide with the Euronaval 2022 world naval defence exhibition. The dislocation that resulted from the COVID-19 pandemic has meant that it is four years since leaders from the world's navies and naval industrial sector were last able to meet face-to-face in Paris. A lot of water has passed under the bridge during the intervening period. The United Kingdom's departure from the European Union, the end of the US Trump administration, the Afghanistan debacle and the Russian invasion of Ukraine, not to mention the ravages of the pandemic itself, are just some of the events that have taken place over this time.

Of these events, it is hard to disagree that President Vladimir Putin's Ukraine "adventure" has had the most impact on the geopolitical stage. The invasion has essentially returned Europe to the days of the Cold War, with all that that entails. Indeed, the potential use of nuclear weapons seems to be an even more imminent threat than it was before. Whatever the outcome in Ukraine, it seems that this is the new strategic reality for the foreseeable future. Whilst attention has inevitably been focused on the Black Sea, the conflict places NATO's northern flank – and particularly – the Baltic in the forefront of a new east/west frontline. Our major interview with Vice Admiral Jan C Kaack, Germany's new "Inspekteur der Marine", highlights some of the practical effects of this new environment, not least the strategic impact of Finland's and Sweden's pending accession to NATO. In this edition, we also examine current naval procurement in the Baltic region and – further afield – the implications of growing strategic competition in the Arctic.

Another inescapable consequence of recent events is the impact on the world's economy. Europe, particularly, will be poorer than would otherwise have been the case due to the spill-over of current tensions into the new front encompassed by today's "energy wars". Until the necessary adjustments to escape past over-reliance on Russian gas can be implemented, Europe's economy will continue to suffer. This, in turn, has implications for the renewal of the region's armed forces – including its navies – that will be required to accommodate the revised security situation. Irrespective of initiatives such as Chancellor Scholz's €100Bn special fund, it seems likely that the demands of naval modernisation will continue to struggle to achieve the requisite funding.

As such, navies will need to strive continuously to achieve operational requirements more efficiently and effectively. Industry, through the development of new technology and mission approaches, undoubtedly has a leading role to play in achieving this objective. Accordingly, this edition looks at many of the new initiatives that are underway, ranging from the ongoing progress with unmanned systems through to work on the new generation of directed-energy weapons. Taken together, a focus on leveraging the West's leadership across a range of technologies has the potential to make a significant difference.

One other consideration must come to the forefront: a sense of urgency. Many of the programmes referred to in this edition have been years in the making. Brazil's new submarine RIACHUELO – delivered on 1 September 2022 – was conceived as a result of contracts signed in 2009; it will be a decade at best before the first German Navy Type 212CD submarine enters operational service. The ever-changing nature of the current strategic environment means that more is needed. A little over a century ago, the battleship DREADOUGHT – just as revolutionary to contemporary commentators as many current systems are today – was taken from concept to operation in under two years. Politicians, industry and navies need to work together to accelerate the process of change as we adapt to a new world order.

Yours Aye
Conrad

Masthead

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Contents

Cover Photo: Delivered in November 2020, the first-of-class of the French Navy's new SUFFREN class nuclear-powered attack submarines entered service on 1 June 2022. Page 10 pp. (Photo: Axel Manzano/Marine Nationale/Défense)

Index of Advertisers

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From the Sea and Beyond

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EUROPE

United Kingdom: Commisisoning of the New Submarine ANSON

(sb) The last day of August 2022 saw the formal commissioning of the ANSON, the fifth member of the British Royal Navy's ASTUTE class of nuclear powered attack submarines, at BAE Systems' Barrow-in-Furness shipyard at northwest England. Displacing some 7,800 tonnes in submerged condition and some 97 metres in length, ANSON was laid down over a decade ago in October 2011 and subsequently launched in April 2021. In spite of the formal ceremony, ANSON has yet to commence her programme of sea trials, which will be carried out after a maiden voyage to the home of the Royal Navy's submarine force at Faslane Naval Base on the Clyde.

More broadly, BAE Systems has now delivered the first four submarines in the ASTUTE class, all of which are currently in service with the Royal Navy. The sixth and seventh boats are at an advanced stage of construction in Barrow. The facility is also working on the assembly of the first two of four DREADNOGHT class strategic submarines whilst early concept and design efforts are also underway on a SSN-Replacement (SSN-R) design that will ultimately replace the ASTUTE class in service.

Photo: BAE Systems

The ASTUTE class submarine ANSON – pictured here shortly before her launch in April 2021 – has now been commissioned into British Royal Navy service.

MDM Editorial Commentary: Construction of the ASTUTE class has had a long and chequered history since contracts for the first three members of the class were signed as long ago as 1997. Many of the early problems with the programme – which were related to a fall-off in submarine orders in the immediate post-Cold War era and a subsequent loss of shipbuilding skills – have long been resolved. However, delivery of the fourth member of the class – AUDACIOUS – was also considerably delayed by significant but undisclosed technical issues that, in turn, had a knock-on effect on ANSON and the two other boats of the class. As a result, there has been significant operational pressure on the Royal Navy's overall submarine force given the need to retire the remaining submarines of the previous TRAFALGAR class as they reached life- expiry. The British Ministry of Defence have taken considerable action to avoid a repeat of these difficulties with the new DREADNOUGHT class boats, which will be crucial to the maintenance of Britain's strategic nuclear deterrent. Current indications are that this programme is progressing far more smoothly but there is limited room for project slippage if these submarines are to become operational as planned during the course of the 2030s.

Meanwhile, ANSON's commissioning ceremony was notable for the presence of Richard Marles, Australia's new Deputy Prime Minister. Australia is currently evaluating options for its own new nuclear powered attack submarine programme under the framework of the AUKUS partnership. It would seem likely that the United Kingdom is keen to encourage Australian participation in the SSN-R project. An announcement made at the ceremony confirmed that Royal Australian Navy submariners would train aboard ANSON and other members of the ASTUTE class.

France: GA-EMS' EMALS, AAG to be Evaluated for France's Next Generation Aircraft Carrier

(jh) General Atomics Electromagnetic Systems (GA-EMS) has announced that it has been awarded a contract by US Naval Air Systems Command (NAVAIR) to continue development and evaluation of tailored configurations of the Electromagnetic Aircraft Launch System (EMALS) and Advanced Arresting Gear (AAG) as a potential Foreign Military Sale to the French Navy for their next generation aircraft carrier, "Porte-Avions Nouvelle Génération" (PANG).

GA-EMS intends to continue evaluating EMALS and AAG configurations for performance and to document ship interfaces and impacts on the PANG. The contract is to culminate in 2023 with a System Requirements Review and an evaluation of French suppliers for potential component manufacturing in France.

According to the company, GA-EMS has participated in carrier studies to investigate the feasibility of implementing EMALS and AAG for the future French carrier design under previous contract awards over the past two years. In December 2021, the US State Department announced it approved a possible Foreign Military Sale for a two EMALS and three AAG configuration to France.

The first-of-class GERALD R. FORD (CVN-78) recently completed its 10,000th successful launch and arrested landing using EMALS and AAG. The systems continue to perform successfully as CVN-78 prepares for its upcoming deployment. GA-EMS is currently under contract with the US Navy to support CVN-78 sustainment requirements and is delivering EMALS and AAG for the next two FORD class carriers currently under construction, JOHN F. KENNEDY (CVN-79) and ENTERPRISE (CVN-80).

Germany: New SEAGUARD 96 Corvette Concept Presented by German Naval Yards Kiel

(hum) German Naval Yards Kiel (GNYK) used the occasion of the SMM Hamburg 2022 trade fair to present its SEAGUARD 96, a new corvette design concept. According

Photo: German Naval Yards Kiel

German Naval Yards Kiel presented its SEAGUARD 96 corvette concept at SMM Hamburg 2022.

to the company, the design represents an "innovative high-end corvette capable of conducting the entire spectrum of naval operations" and – in common with many other recent concepts – incorporates a high level of modularity so as to facilitate configuration to meet specific customer requirements. The new concept's basic design is derived from related company Constructions Mécaniques de Normandie's (CMN's) 2014 C SWORD 90 concept and, although differing in many details, has been developed in collaboration with the French yard. Some 96 metres long and 13.5 metres in breadth, the 2,000 tonne displacement SEAGUARD 96 incorporates a diesel propulsion system that combines a respectable 28-knot top speed with range of around 3,800 nautical miles at 15 knots. A lean crewing concept is reflected in an accommodation capacity for 60 personnel.

SEAGUARD 96 will enter a crowded and competitive market, making the decision to launch a new product an interesting one. Accordingly, there has been some speculation that the ship's launch should be seen in the context of GNYK and CMN parent Privinvest group's desire to strengthen its negotiating position in attempting to secure consolidation within both the German and wider European naval shipbuilding sector.

Sweden: Contract for SÖDERMANLAND Submarine Life-Extension

(cw) Sweden's Saab has announced contracts valued at SEK 470M (circa US$45M) encompassing the life extension of the submarine SÖDERMANLAND and various orders for new submarine batteries and battery development. The life-extension element of the contracts is reported to encompass around 50 modifications and will allow the veteran boat – first built in the late 1980s – to enjoy a further six years of operational service. The decision to extend her life might reflect delays to the replacement A26 BLEKINGE class programme, which is further discussed in a review of the Baltic Navies contained later in this edition.

Photo: Saab AB

Saab has received a contract to extend the life of the submarine SÖDERMANLAND for a further six years.

THE AMERICAS

Brazil: SCORPÈNE Type Submarine RIACHUELO Commissioned

(cw) The Brazilian Navy's "Programa de Desenvolvimento de Submarinos" (PROSUB) achieved a major milestone on 1 September 2022 with the commissioning of RIACHUELO, the first of a total of four planned SCORPÈNE type diesel-electric submarines that are scheduled to be delivered under the massive project. The ceremony took place at the Itaguaí Naval Base, which forms just one part of the substantial new infrastructure that has been constructed to ensure the delivery and subsequent support of the navy's new submarine flotilla. Implementation of the programme is being carried out by Itaguaí Construções Navais SA (ICN) – a special purpose entity established by Novonor (formerly Odebrecht) and Naval Group as a result of a series of contracts reportedly valued at around €7Bn signed by the French company in September 2009. These contracts included support for creation of a new naval shipyard and base complex, transfer of technology to assist with the construction of the submarines and the supply of material and weapons for the new flotilla.

Naval Group describes RIACHUELO as a 2,000-tonne conventional submarine variant of the SCORPÈNE type that is designed for all kinds of missions, including the performance of anti-surface warfare, anti-submarine warfare, long-range strike, special operations and intelligence gathering duties. Claimed to be extremely stealthy and fast, it incorporates a level of operating automation that facilitates use of a limited crew-size to reduce its operating costs significantly. Its combat edge is provided by six weapon launching tubes for up to 18 torpedoes and missiles. A total of 14 SCORPÈNE type submarine variants have been sold to date, with RIACHUELO and her sister boats being slightly stretched from previous members of the class. Other SCORPÈNE operators currently comprise Chile, India and Malaysia.

Photo: Brazilian Navy

Brazil's new SCORPÈNE type submarine RIACHUELO pictured at her commissioning ceremony at the Itaguaí Naval Base.

MDM Editorial Commentary: RIACHUELO's commissioning marks the culmination of a lengthy construction and delivery process that began with a first steel-cutting ceremony on one of the French-built, forward sections of the boat in May 2010 at Naval Group's shipyard in Cherbourg (construction activities began in France because the necessary Brazilian infrastructure was not complete so early in the programme). Progress with the submarine was subsequently delayed by Brazil's economic crisis and it was not until December 2018 that she was lowered into the water by means of the ship lift at Itaguaí. The subsequent trials and delivery phase was further pushed back by an accident in March 2021 that caused salt water flooding of her bow area. Accordingly, both ICN and the Brazilian Navy will doubtless be relieved she has now been formally commissioned into naval service.

Construction activities continue at Itaguaí on the three remaining boats, with second-of-class HUMAITÁ – launched in December 2020 – scheduled to commence trials around the time this edition of MDM was due to go to press. Present plans envisage all four new submarines should be operational by 2025, several years later than initially planned. In the longer term, progress with completion of the SCORPÈNEs should allow the Brazilian Navy to place greater focus on its plans to construct an indigenous nuclear powered attack submarine; an ambition that it has harboured since as far back as the 1970s. Much design and development work on the so-called SN-BR – provisionally named ÁLVARO ALBERTO – has already been completed, with technical and design assistance for the non-nuclear aspects of the SN-BR programme also being provided by Naval Group under the contracts concluded in 2009. However, it remains to be seen whether planned completion of the new boat in the course of the 2030s is a realistic objective given overall funding constraints on both the Brazilian Navy and the wider Brazilian armed forces.

Canada: Third Royal Canadian Navy Arctic and Offshore Patrol Ship Delivered

(cw) The Royal Canadian Navy's Arctic and Offshore Patrol Ship (AOPS) programme reached its halfway mark on 2 September 2022 with the delivery of MAX BERNAYS, the third of six HARRY DE WOLF class vessels delivered under a contract initially signed in 2014. All the ships are being built by Irving Shipbuilding at Halifax, Nova Scotia under the framework of Canada's controversial National Shipbuilding Strategy. Whilst making meaningful progress in revitalising Canada's previously moribund shipbuilding sector, the policy has arguably resulted in the Canadian taxpayer paying significantly more for new government vessels than if they had been ordered from overseas yards. Irving Shipbuilding is scheduled to deliver the three remaining Royal Canadian Navy AOPS type vessels at the rate of one per year between 2023 and 2025. It will then deliver an additional pair of the type to the Canadian Coast Guard over the following two years. This will essentially smooth transition of shipyard production to the new Canadian Surface Combatant (CSC) programme. The initial orders for what is ultimately expected to be a 15-ship class based on the British Type 26 frigate design are expected to be placed over the course of the next year.

Photo: Irving Shipbuilding

MAX BERNAYS (right) pictured at the time of an unusual joint naming ceremony with her sister AOPS – the already delivered MARGARET BROOKE – at Irving Shipbuilding's Halifax Shipyard on 29 May 2022. MAX BERNAYS has now also been delivered.

Colombia: Damen Selected as Design Partner for New Frigates

(cw) In late September 2022, the Colombian Ministry of Defence announced that the Damen had been selected as design partner to support the construction of a new class of frigates included within the framework of the navy's "Plataforma Estratégica de Superficie" project. It is envisaged that the new ships will be built indigenous by local shipbuilder COTECMAR with the help of Damen's technological assistance. An image released to support the announcement suggests that the Dutch group's SIGMA (Ship Integrated Geometrical Modularity Approach) 10514 hull will form the basis of the design. The fact that this design has already been subject to successful "in country" construction under transfer of technology agreements with Indonesia and Mexico was doubtless an important factor in Damen's success.

The new frigates will ultimately replace the existing quartet of German-built FS-1500 ALMIRANTE PADILLA class light frigates that currently form the core of the surface fleet. There had been speculation that this replacement was potentially vulnerable to recent change in Colombia's political leadership. Accordingly, selection of Damen to progress the project is likely to alleviate some of these concerns.

Photo: US Navy

Colombia has selected Damen as design partner for its "Plataforma Estratégica de Superficie" project. This picture shows Damen-designed SIGMA 9113 and 10514 vessels in Indonesian Navy service.

United States: Work Starts on Lead CONSTELLATION Class Frigate

(cw) The US Navy's lead CONSTELLATION (FFG-62) class frigate commenced construction at Fincantieri Marinette Marine shipyard in Marinette, Wisconsin on 31 August 2022. According to a US Navy press release, the start of construction followed a detailed navy assessment of the maturity of the design and the readiness of the shipyard to begin construction after completion of a successful production readiness review milestone on 20 July 2022. Ordered on 30 April 2022, CONSTELLATION is expected to be delivered in 2026 and enter operational service before the end of the decade. A further two members of the class have been contracted to date following the exercise of an option for a third vessel, CHESAPEAKE (FFG-64) in June 2022.

MDM Editorial Commentary: Derived from the Italian variant of the Franco-Italian FREMM multi-mission frigate, the CONSTELLATION class is intended to form the basis of future US Navy small surface combatant construction after growing dissatisfaction with the previous littoral combat ship concept resulted in that programme's curtailment. Current plans envisage a total of 20 members of the class ultimately being acquired by the mid-2030s, although this number might be expanded given the requirement for a total of 56 small surface combatants outlined in the US Navy's latest "Navigation Plan 2022", Whilst the CONSTELLATION class owes much to the FREMM, its design has been significantly adjusted to accommodate a US-specific combat suite that will include the AEGIS combat system, a three-faced, AN/SPY-6(V)3 variant of the ENTERRPISE AIR SURVEILLANCE RADAR (EASR) and a 32-cell MK 41 vertical launch system. This has resulted in the ship's physical dimensions being stretched to meet the additional volume and topweight required by the changed systems, as well as a redesigned superstructure. Displacement has reportedly increased from 6,900 to 7,400 tonnes. Perhaps unsurprisingly, the detailed design work to accommodate these changes has taken time. Accordingly, previous plans to commence construction of the lead ship firstly late in 2021 and then by April 2022 have not been met.

Photo: US Navy

The US Navy has commenced construction of its lead CONSTELLATION (FFG-62) class frigate after a number of delays.

Australia: Progress with HUNTER Class Frigate Programme (cw) In August 2022, BAE Systems Australia announced the completion of the first prototype block fabricated as part of preparations for the start of physical construction on the Royal Australian Navy's new HUNTER class frigates. Manufactured at the Osborne Naval Shipyard in South Australia, the block is one of five that are intended to test and refine processes, systems, tools, facilities and workforce skills before full-scale production of the new ships gets underway. It is currently intended that the fourth and fifth blocks – on which work will commence in the course of mid-2023 – will be used in one of the first three ships of the nine frigate class, marking the transition to the start of work on the programme proper.
The first prototype block is identical to those being constructed for the British Type 26 frigates from which the HUNTER class is derived and does not incorporate any of the specific adjustments made to the Australian variants. One of 22 blocks that comprise each ship, the prototype Block 16 weighs a total of 141 tonnes and has utilised a total of 45,000 man hours of work since fabrication commenced in December 2020. BAE Systems Australia states that a total of 35 trades have been used in its completion, including engineering, boiler-making, fabrication, project management and construction.

MDM Editorial Commentary: The successful completion of the first HUNTER class prototype block is a welcome development for BAE Systems and the HUNTER class programme, which has come under sustained criticism from parts of the Australian media. This criticism has been diverse in nature but has essentially focused on early delays to the schedule and questions as to whether the HUNTER class design is the right ship for Australia's needs. As a result, there has been some speculation that the new Australian government might look to adjust or even cancel the entire project.
Many of the early challenges that the HUNTER class programme has had to overcome relate to adjusting the parent design to meet Australian requirements, including incorporation of the AEGIS combat system and the indigenous CEAFAR 2 multi-function radar. These have reportedly increased overall full load displacement to around 10,000 tonnes and inevitably pushed against overall design margins. However, the design successfully passed a system definition review earlier in 2022 and seems to be steadily moving onto a firmer footing. It is also questionable whether any of the alternative designs shortlisted to meet Australia's requirements would have had a smoother passage given they were smaller and incorporated less margin for change than the Type 26. In any event, neither the Australian shipbuilding sector nor the Royal Australian Navy is in any position to accommodate further changes to procurement plans given the delay and disruption that has been caused by the abandonment of the ATTACK class submarine programme as part of the new AUKUS arrangements.


Photo: BAE Systems

A computer generated image of the HUNTER class frigate design.

India: Aircraft Carrier VIKRANT Commissioned

(cw) India's first indigenous aircraft carrier, VIKRANT, was finally commissioned into Indian Navy service at builders Cochin Shipyard Ltd on 2 September at an event attended by Indian Prime Minister Narendra Modi, Defence Minister Rajnath Singh and other dignitaries. She had previously been accepted by the Indian Navy on 28 July. The ship's completion, some 13 years after she was laid down, means that India joins one of only a handful of nations able to design and build ships of this type. However, flying trials have yet to be completed and it will be some while yet before she enters service. VIKRANT's induction is discussed in more detail in a special article in this edition.

New Zealand: Frigate TE MANA Completes Mid-Life Upgrade

(cw) The Royal New Zealand Navy's Frigate Systems Upgrade has been brought to a close with the return of TE MANA to Auckland in July 2022. The programme commenced as long ago as April 2014 when Lockheed Martin Canada was selected over several other international bidders to become prime systems integrator to upgrade the combat systems on New Zealand's two ANZAC class frigates. The upgrade has delivered a range of new equipment – including a Thales SMART-S Mk 2 radar, CAMM surface-to-air missiles, Rheinmetall MASS decoy launchers and Ultra's SEA ENTOR torpedo defence system – that is integrated with the company's CMS 330 combat management system. The intention is that the modernisation will allow the frigates to remain in service out to 2035, when they will be replaced by new ships.


Photo: Royal New Zealand Navy

TE MANA on her return voyage to New Zealand following completion of her mid-life upgrade.

Physical implementation of the programme commenced on TE KAHA at Seaspan's Victoria Shipyards in Canada in 2018, with TE MANA entering upgrade the following year. The programme has proved significantly more costly than initially expected whilst a number of challenges, not least the onset of the COVID-19 pandemic, delayed its completion. The additional costs have had a particularly negative impact on the Royal New Zealand Navy, influencing the curtailment and postponement of a number of other naval programmes.

The Philippines: New Construction Programmes Approved

(cw) The Philippine Navy has benefited from a series of procurement announcements over recent months as the departing Duterte administration rushed to conclude key elements of the 2018-2022 'Horizon 2' phase of the Revised Armed Forces of the Philippines Modernization Program (RAFPMP) before leaving office. Notably, on 27 June 2022, South Korea's Hyundai Heavy Industries (HHI) released details of a contract for the supply of six 2,400 tonne offshore patrol vessels that will be acquired at a total cost of US$557m. The new patrol ships will be armed with a 76mm gun and will be able to operate a helicopter and/or unmanned aerial vehicles. The contract follows a previous deal concluded in December 2021 encompassing two new corvettes reportedly based on HHI's 3,100 tonne, 118 metre HDC-3100 design and the earlier delivery of the HHI-built pair JOSE RIZAL class frigates in 2020-21. Whilst therefore facilitating consolidation on a homogenous force of new surface warships, the latest deal will be a disappointment to Australia's Austal, which previously had entertained hopes of building the patrol ships in its local facility in the Philippines.


Photo: US Navy

The Philippine Navy is acquiring a second pair of TARLAC class amphibious transport docks to join the two members of the class that are already in service.

Another contract announced in June 2022 was an agreement with Indonesia's PT for the purchase of a second pair of TARLAC class amphibious transport docks, which are derived from the Indonesian Navy's South Korean designed MAKASSAR class. Philippine maritime capabilities will also benefit from the January 2022 deal that involves the acquisition of three batteries of Indo-Russian BRAHMOS surface-to-surface missiles that will be operated by the Philippine Marine Corps, markedly improving Philippine Anti-Access/Area-Denial (A2/AD) capabilities across the contested South China Sea.

Looking to the future, an inevitable question is whether the recent improvement in the Philippine Navy's fortunes will be sustained during the 'Horizon 3' stage of the modernisation programme after assumption of political control by the new Marcos administration on 1 July 2022. If this phase of military renewal follows previous assumptions, its successful achievement could see the Philippine Navy acquire an embryonic submarine capability by the end of the current decade.

Thailand: Elbit to Supply HERMES 900 UAS to the Royal Thai Navy

(jh) Elbit Systems has announced that it has been awarded a contract valued at US$120M to supply HERMES 900 Maritime Unmanned Aircraft Systems (UAS) and training capabilities to the Royal Thai Navy. Under the contract, Elbit Systems will provide the navy with an undisclosed number of Hermes 900 Maritime UAS incorporating maritime radar, an electro-optic payload, satellite communications and other equipment. Elbit state that the new systems will help Thailand perform blue water and littoral missions, communicating with naval vessels and carrying out missions such search and rescue and the identification of suspicious activities and potential hazards.


Photo: Elbit Systems

The Royal Thai Navy is acquiring the HERMES 900 UAS.

Africa & the Middle East

Saudi Arabia: Fleet Renewal Advances

(cw) The extensive renewal of the Royal Saudi Navy with new warships under the Saudi Naval Expansion Programme II (SNEP II) saw a further development in late July with the delivery of the second AL JUBAIL class AVANTE 2200 type corvette at Navantia's San Fernando facility in the Bay of Cadiz. The new AL DIRIYAH was handed over on 26 July 2022, a little over three years since fabrication of the vessel commenced in May 2019. A press release produced by Navantia to mark the event highlighted the fact that the ship's construction had met the required delivery schedule in spite of the impact of the COVID-19 pandemic and the related effect on global supply chains.

A further three ships of the AL JUBAIL class remain to be delivered under a contract that entered into force in November 2018 and is expected to be concluded by 2024. The Royal Saudi Navy is also expected to see the start of deliveries of four, larger multi-mission surface combatants from the United States-based Fincantieri Marinette Marine that are derived from the FREEDOM (LCS-1) design within the same timeframe.


Photo: Navantia

Navantia is making good progress with construction of Al-JUBAIL class corvettes – the lead ship AL JUBAIL is pictured here –with the second ship, named AL DIRIYAH, now delivered to the Royal Saudi Navy.

WATCH BILL

New Leadership for Elbit Systems Deutschland

Photo: Elbit Systems Deutschland)

Gregor Zowierucha

(hum) At the beginning of July 2022, Gregor Zowierucha took over the management of the system house Elbit Systems Deutschland GmbH & Co. KG. The company – a subsidiary of Israel's Elbit Systems since 2007 – has extensive expertise in communications and data links, cyber security, electro-optical systems and solutions for the digital battlefield.

According to an Elbit press release, Zowierucha, who has a degree in industrial engineering, previously held various management positions in the German defence industry, including at ESG in the Mission Aircraft and Unmanned Systems divisions and most recently at Rheinmetall in Bremen. Prior to that, after completing his general staff course, he served in the German Armed Forces, first as an officer in the Centre for Intelligence and, after his Afghanistan deployment, was assigned to posts in the German Embassy in Washington DC, the Operations Command and the Federal Ministry of Defence. Zowierucha succeeds long-time managing director Thomas Nützel at the helm of Elbit Systems Germany, who is retiring.

Dirk Lesko Appointed President of Irving Shipbuilding

(cw) Canada's Irving Shipbuilding Inc. has appointed Dirk Lesko, the former head of General Dynamics Bath Iron Works (BIW), as its new President. A Maine native, Mr Lesko earned a Bachelor of Science degree in Business Administration from The University of Maine and a Master of Science Degree in Business Administration from Boston University. He enjoyed a lengthy career at BIW before his unexpected resignation in April 2022 (see Periscope, MDM June 2022). His appointment will bring significant expertise of managing large warship construction to the Canadian shipbuilder, which is shortly due to embark on the new Canadian Surface Combatant programme. Mr Lesko assumed his new duties on 1 September 2022.

Photo: Irving Shipbuilding

Dirk Lesko

French Naval Procurement Programmes: Status Report

Bruno Huriet

A few sentences recently pronounced by Admiral Pierre Vandier, the Marine Nationale's Chief of Staff, provide a good idea of the French Navy's current situation: "You are entering a navy that is probably going to face fire (combat) at sea", he declared a few months ago to Naval Academy cadets. "Despite all that has been done, the size of the navy will continue to decrease for the next two years. Since 1945, the size of the Navy has never been as small as it is today," he told members of the Defence Committee in July 2022. It is therefore vital to continue the programmes that have been started and to launch those necessary "...to guarantee the coherence of our operational contracts: mine warfare vessels...ocean-going patrol vessels...the successor to the ATLANTIQUE 2, the future aircraft carrier...and the third generation strategic submarines".

The French Navy is, therefore, in a critical period. Some modernisation efforts have started to show good results but important decisions must be taken if France wants to remain a globally significant navy. There are, however, promising signs. French military programmes are planned and financed through a "Loi de Programmation Militaire" (LPM), a military spending plan subject to parliamentary approval that spans a period of six years. The current LPM covers the period 2019-2025. Every year, parliament discusses the planned payments under the LPM; as it is only a plan, changes – usually delaying or curtailing projects – can easily happen. However, for the first time in many years, the commitments approved are being respected without reduction. This is allowing the programmes discussed below to proceed in line with expected plans.

Photo: Naval Group

Replacing the strategic submarines that provide France's underwater deterrent with the new SNLE 3G will be the French Navy's most costly programme of the coming decades.

Third Generation Strategic Submarines (SNLE 3G)

The first mission of the French Navy is to ensure strategic deterrence: the Marine Nationale is responsible for a major component of France's overall nuclear force through its "Sous-marin Nucléaire Lanceur d'Engins" (SNLE) type submarines that each carry 16 missiles with a payload of some six to ten warheads. Moreover, the navy is also able to contribute to France's airborne deterrent arm through arming its RAFALE multi-role fighters with the "Air-Sol Moyenne Portée (ASMP-A) air-to-ground medium range nuclear missile. One SNLE is always at sea, ready to receive a firing order from the President. Another is ready to replace it at short notice with the other two submarines undergoing different maintenance phases.

The four LE TRIOMPHANT class strategic submarines were commissioned between 1997 and 2010; the three oldest were modernised between 2013 and 2019 to match the standards of the fourth and newest boat. This included the ability to carry the new M51 ballistic missile, the integration of a new combat system and improvements to the sonar suite. Subsequently, on 19 February 2021, the then Minister of the Armed Forces Florence Parly launched the renewal of this component of the deterrent: from 2035, and every five years thereafter, a new strategic submarine will be delivered. This programme is known as the SNLE 3G or third generation strategic submarine. Naval Group is already undertaking the necessary design studies and orders have also been placed with key suppliers for specific components

Author

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such as elements of the propulsion plant and missile launch tubes. First steel cutting is scheduled for 2023 in Cherbourg. The new SNLEs will be "slightly larger than the LE TRIOMPHANT class" and obviously quieter but further details available at present are limited.

New Generation Aircraft Carrier (PANG)

The French Navy's second major project is for a successor to the aircraft carrier CHARLES DE GAULLE. The end of her operational life is scheduled for 2038 so her successor must be in service before that date. The subject of a new aircraft carrier, including the choice between building one or two, had been discussed by all French governments for over 20 years, without any firm decision being taken. Today, with only one carrier, France is left without the capacity she provides when she is undergoing maintenance. However, on 8 December 2020, President Macron took a major step forward with regard to CHARLES DE GAULLE's replacement by announcing that a new aircraft carrier with nuclear propulsion would be built. The project is referred to as the "Porte-Avions de Nouvelle Génération" (PANG).

Preliminary design is currently underway. This is entrusted to a partnership between Naval Group and Chantiers de l'Atlantique and will last until March 2023. This will be followed by more detailed studies which will conclude, if the planned trajectory is maintained, with an order for the ship's construction in 2028. This would allow delivery by the all-important 2038 deadline for CHARLES DE GAULLE's retirement. Naval Group, the lead contractor, is responsible for the overall architecture of the ship, for combat system integration, and navigation and aviation-related systems. It will also be responsible for integrating the nuclear propulsion plant into the ship. Construction will take place at the Chantiers de l'Atlantique shipyard in Saint Nazaire, which will build, in the words of its Chief Executive Officer, "everything around the nuclear power plant". French nuclear naval propulsion specialist Technicatome will design the new ship's nuclear propulsion system. This will be based on two new 220MW K22 reactors that will produce more power than the two 150MW K15 types that equip CHARLES DE GAULLE.

Photo: Naval Group

A computer generated image of France's "Porte-Avions de Nouvelle Génération" (PANG).

Information released to date indicates that the future aircraft carrier will be longer (305 metres compared to 261 metres for the CHARLES DE GAULLE) and have a greater displacement (75,000 tonnes compared to 42,500 tonnes) than her predecessor. She will carry the successor of the RAFALE fighter, the NGF (Next Generation Fighter) – a cooperative programme with Germany, Spain and France – if current difficulties between the partners with respect to management of the programme are overcome. In similar fashion to CHARLES DE GAULLE, launch and recovery of aircraft will be by a Catapult Assisted Take Off But Arrested Recovery (CATOBAR) system. However, the steam catapults used on France's previous carriers will be replaced by the Electro-Magnetic Aircraft Launch System (EMALS) produced by US company General Atomics and already produced for the FORD (CVN-78) class carriers. Advanced Arresting Gear (AAG) will be acquired from the same supplier.

France's new Minister of Defence, Sébastien Lecornu, has indicated that the subject of purchasing a second aircraft carrier to enable an air group to be permanently available at sea will be discussed during the preparation of the next LPM.

Photo: Naval Group

The formal keel laying for the first of France's five AMIRAL RONARC'H class frigates of the FDI type took place at Lorient during December 2021.

FDI Frigates

As a result of the Defence White Paper of 2013, the French Navy's structure has been set at 15 front line frigates ("frégates de premier rang"). Previous French Navy Chiefs of Staff have repeatedly argued that 18 frigates should be the appropriate target, but without success. The figure of 15 will be achieved with delivery of LORRAINE, the final FREMM type frigate.


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Photo: Bernard Prézelin

The first of the French Navy's new SUFFREN class nuclear-powered attack submarines pictured off Brest in the course of trials.

Frigate fleet composition is currently:

- Two FORBIN class air defence frigates – "Frégate de Défense Aérienne" (FDA) – displacing circa 7,100 tonnes and which would be categorised as destroyers in most navies.
- Eight AQUITAINE class frigates of the FREMM multi-mission type displacing circa 6,000 tonnes.
- Five LA FAYETTE class light stealth frigates displacing circa 3,800 tonnes.

Of these, the LA FAYETTE type is of limited military value with no Anti-Submarine Warfare (ASW) capacity and limited self-defence systems. Three are currently undergoing a midlife upgrade to add a Thales KINGCLIP Mk2 sonar and MISTRAL 3 short-range missiles to help bridge the capability gap before their replacements arrive.

These comprise five "Frégate de Défense et d'Intervention" (FDI) type frigates ordered from Naval Group in 2017. The keel of the first – AMIRAL RONARC'H – was laid at Lorient in December 2021: she should commence sea trials in the summer of 2023 and be delivered the following year. The Lorient site will then build three frigates of the same type for the Greek Navy, delaying delivery of the remaining French vessels to the 2026-2029 timeframe.

These 4,500-tonne frigates, called BELH@RRA on the export markets, have a length of 120 metres. They are powered four MTU 16-8000 diesel engines providing a total output of 32MW and which drive two shaft lines in CODAD configuration. They are designed for anti-surface, anti-air, ASW and Special Forces missions and incorporate the following equipment:

- A 76mm main gun.
- Eight EXOCET MM40 Block 3C surface-to-surface missiles.
- A Vertical Launch System (VLS) for 16 ASTER 15 and ASTER 30 surface-to-air missiles.
- Two twin torpedo tubes for MU90 ASW torpedoes.
- An ASW detection suite comprising a KINGCLIP Mk 2 hull sonar and CAPTAS-4 towed array sonar.
- A SEA FIRE multifunction radar incorporating four Active Electronically Scanned Array (ASEA) antennae that can provide simultaneous air, surface and fire control functions.
- A hangar and flight deck for an NH-90 sized medium helicopter and/or an unmanned rotorcraft.

Naval Group emphasise that these ships are entirely configured for the digital age. An interest feature is the provision of two redundant data centres fully protected against Cyber Warfare attack.

SUFFREN Class Nuclear-Powered Attack Submarines (SNAs)

France's flotilla of nuclear-powered attack submarines – "Sous-marins Nucléaires d'Attaque" (SNAs) – is currently focused on the five surviving members of the original six-strong 2,700-tonne RUBIS class that were commissioned between 1983 and 1993. These units are in great demand; escorting the SNLEs when they deploy or return to base, accompanying the aircraft carrier group, collecting intelligence in "hot areas" and performing other covert operations. However, their increasing age has mandated their replacement and, indeed, a "BARRACUDA" programme with this end in mind was launched as long ago as 1998. However, budgetary reasons delayed progress and it was not until 2007 that the first of the class commenced construction at Cherbourg. Named SUFFREN, the new submarine undertook her first dive in August 2020. Delivered in November that year, she entered the operational fleet on 1 June 2022 after numerous trials and deployments across the world's oceans. Five more submarines of the class will follow SUFFREN, with deliveries scheduled for every two years.

Compared to the previous RUBIS class, SUFFREN is larger (5,300 tonnes with a length of 99.5 metres), has more autonomy, is quieter and can dive deeper. She also offers superior habitability for a slightly smaller (65 compared with 70) crew.

SUFFREN is equipped with a SYCOBS ("Système de Combat Commun Barracuda et SNLE") combat management system that was first introduced in the final LE TRIOMPHANT class strategic submarine, LE TERRIBLE. A Thales-supplied sonar suite includes a bow mounted cylindrical array, planar flank arrays and a mine avoidance sonar. Two non-penetrating optronic masts and a radar mast were supplied by Safran. Four 533mm torpedo tubes can launch a mixture of weapons including F21 heavyweight torpedoes, EXOCET anti-shipping missiles and MdCN cruise missiles, the latter being the naval version of the STORM SHADOW/SCALP air-launched cruise missile. This provides the French Navy with an enhanced deep strike capacity against land targets; an ability that was not provided in the RUBIS class.

The possibility of carrying out Special Operations has also been reinforced: provision is made to accommodate a group of Special Forces on board and it is possible to attach a dry deck shelter. This will allow for easier deployment of Special Forces and their equipment, including inflatable boats and swimmer delivery vehicles. In the RUBIS class, deployment was usually by means of the torpedo tubes.

Other Procurement Programmes

In addition to these four major programmes, several other important acquisitions projects are also underway that are essential for the French Navy's future capabilities. These encompass:

Fleet Replenishment Tankers – "Bâtiments Ravitailleurs de Forces" (BRF): There can be no distant deployments without the presence of a fleet tanker able to perform replenishment at sea. With only two old sin-

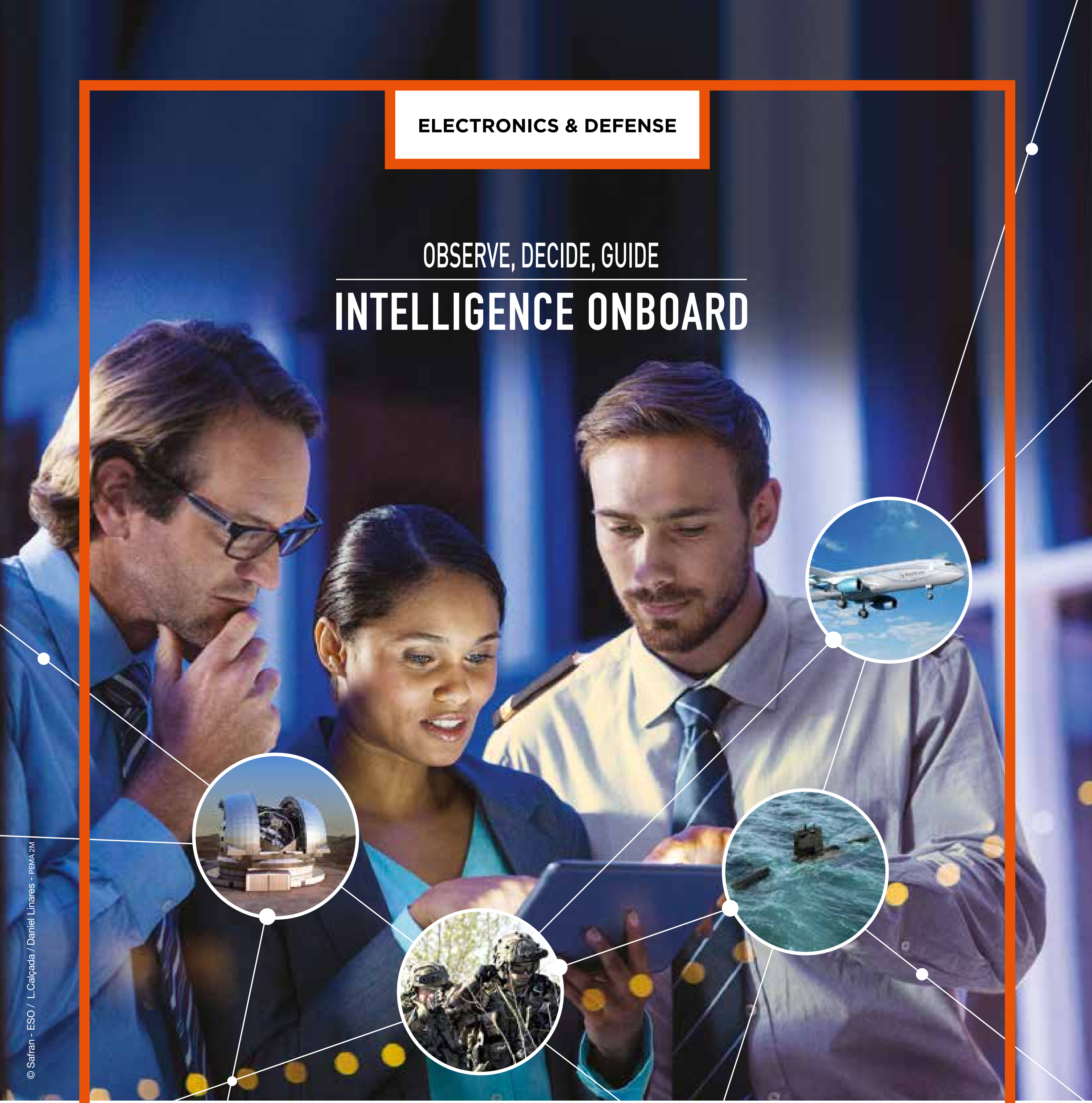
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Photo: Bruno Huriet

The new fleet replenishment tanker JACQUES CHEVALLIER is floated out from the Chantiers de l'Atlantique shipyard in Saint Nazaire in April 2022.

gle-hull tankers of the DURANCE class left in service, the French Navy is currently vulnerable in this regard. However, construction of four new fleet replenishment tankers has started. The first of class, JACQUES CHEVALLIER, is currently afloat and being outfitted at the Chantiers de l'Atlantique in Saint Nazaire; she should be commissioned in 2023. The other three will follow every two years. Displacing some 31,000 tonnes, they will be able to transport 13,000m³ of fuel and 1,500 tonnes of solid cargo.

Patrol Vessels: The means of protecting the maritime approaches to France and its overseas territories currently suffers from a significant capacity deficit that will only be made good around 2030. Two programmes that are at different stages – one for oceanic patrol vessels and one for overseas patrol vessels – will be the means of resolving the current gap.

The oceanic patrol vessels – "Patrouilleurs Océaniques" (PO) – carry out surveillance missions in France's maritime approaches, escort the strategic submarines on their departure and return and undertake longer-range deployments in the fight against maritime crime as far as Africa. These duties are currently carries out by six old A69 corvettes and three smaller vessels that are increasingly unsuited for their tasking and which should have been replaced several years ago. Unfortunately, the necessary decision was postponed a number of times due to budgetary factors. However, Naval Group has now received an order for the detailed design of ten ships that will be 90 metres long and displace 2,000 tonnes; an order for construction is anticipated around the end of 2022. The ships will be built by three smaller companies – CMN, Piriou and Socarenam – for delivery between 2025 and 2030. Limited information on likely equipment suggests armament will encompass a 40mm RAPIDFIRE gun, a sonar system and a platform and hangar for a medium-sized helicopter.

The requirement for the overseas patrol boats – "Patrouilleurs Outre-Mer" (POM) – reflect the fact that France has the second largest Exclusive Economic Zone (EEZ) in the world. However, the means to monitor these immense spaces are currently insufficient; as a former prime minister once said, "what is not monitored is plundered, what is plundered ends up being contested". After years of withdrawing old patrol boats, which led to this lack of capacity, an order for six new POM type patrol vessels was placed with the Socarenam shipyard in 2019. The first – AUGUSTE BÉNÉBIG – is undergoing sea trials and is due to be delivered in 2023. The others will follow until 2025, with all being based in the French overseas territories. The POM is a 1,300 tonne, 80 metre-long vessel equipped with a 20mm NARWHAL cannon and machine guns. A platform allows a helicopter to be landed but there is no helicopter hangar as it is planned to embark an aerial surveillance drone. Missions include surveillance, maritime security in the fight against illegal fishing and various types of trafficking, search and rescue and pollution control.

Surveillance Frigates: Six surveillance frigates are also based overseas. Commissioned between 1992 and 1994, they were built to civilian standards and carry one 100mm and two 20mm guns. Plans for replacement of these vessels must also be taken forward within the next few years. It seems probable that the European Patrol Corvette (EPC) programme supported by the European Union and in which Naval Group is participating alongside Fincantieri and Navantia will ultimately meet this requirement.

Mine Countermeasures: This mission is currently carried out by ten TRIPARTITE minehunters of the same type used by the Belgian and Dutch navies. Constructed from GRP, they can detect, inspect and neutralise mines. Their replacement will be an autonomous, modular concept being developed under the Franco-British Maritime Mine Counter Measures (MMCM) programme, which is being led by Thales as systems integrator. The principle is to remove man from the minefield, using autonomous, modular systems. Each MMCM system is envisaged as comprising:

- Two 12 metre-long Unmanned Surface Vessels (USVs) fitted with an autonomous navigation system and an obstacle avoidance sonar. They will be able to deploy synthetic aperture mining detection imaging sonar or a ROV equipped with single shot mine neutralisation systems to identify and destroy mines.
- Two Autonomous Underwater Vehicles (AUVs) that can carry similar equipment to the USVs but which can operate more discretely and at greater depths.

Photo: Cindy Luu/Marine Nationale/Défense

The French Navy's six surveillance frigates, which are used for overseas presence missions, will need to be replaced within the next few years. This is VENTÔSE in November 2020.

Photo: Bruno Huriet

The French Navy needs to retire legacy helicopter types such as the ALOUETTE III, which is currently undertaking its last operational deployments.

- A Portable Operational Centre (POC) from which operators can monitor and control the remote systems. This can be located ashore or on ship.

France has ordered an initial batch of four systems under the programme and the first operational unit should be delivered in 2023. In the meantime, prototypes continue to be tested by both navies. The technology can be deployed very quickly worldwide as it is possible to transport it by plane. The French Navy also intends to acquire dedicated motherships – "Bâtiments de Guerre des Mines" (BDGM) – to facilitate deployment of these systems but no contracts have been signed to date.

Naval Aviation

France's "Aéronavale" (Naval Aviation) currently operates 22 ATLANTIQUE 2 long-range maritime patrol aircraft. These have been progressively modernised to the current Standard 6 but their age mandates that they must be replaced by the middle of the next decade. A cooperative Franco-German project had been launched for a successor Marine Airborne Warfare System (MAWS) but Germany's decision to turn to Boeing with an order for the P-8A POSEIDON has put this plan into question. A decision on the way forward will be needed soon if the deadline is to be met.

The navy also needs to replace its aging DAUPHIN and PANTHER – as well as the about to be withdrawn ALOUETTE III – helicopter types. It has been determined that the French Armed Forces will purchase 169 H160M helicopters from Airbus, including 49 for the navy. But these six tonne class machines will only be delivered from 2027 onwards. The navy has therefore decided to lease more recent DAUPHIN type helicopters – as well as six basic H160 types not suitable for shipboard operation – for training and search and rescue missions until the new type is a ready.

The Future

Upcoming parliamentary discussions regarding the military budget for 2023 – and even more importantly preparation of the next military spending plan – will be vital in confirming programmes that are essential for the French Navy's current renewal. Over the centuries, the words of Richelieu, "The tears of our sovereigns often have the salty taste of the sea they ignored", have been frequently validated. The coming years will show if this is again to be the case.

Regionally Rooted – Globally Committed: The German Navy's Response to Current Challenges

Photo: Bundeswehr / Nico Theska

In an interview with MDM's joint editor-in-chief Hans Uwe Mergener, Vice Admiral Jan C Kaack, "Inspekteur der Marine" (Chief of the German Naval Staff), delves into how the German Navy is facing up to current challenges. The impending NATO membership of Finland and Sweden will, in the opinion of the head of Germany's navy, become a strategic game changer.

Russia's full-scale invasion of Ukraine has led the German Navy to increase its operational presence along NATO's northern flank and in the Baltic Sea. Just two days after Russian troops invaded Ukraine, on Saturday, 26 February, the fleet service boat ALSTER left its home port in Eckernförde. Her mission: to perform electronic reconnaissance of the sea and coastal areas bounded by the Baltic Sea. Obtaining a consolidated picture of the situation, to which German reconnaissance units contribute, is especially important for the German Navy, the Bundeswehr and the wider NATO alliance in the kind of situation that had developed.
At about the same time, 150 km to the southwest, Siemtje Möller, Parliamentary State Secretary in the German Ministry of Defence, bid farewell to the corvette ERFURT at the Wilhelmshaven naval base. She had left her home port of Warnemünde on 19 February, heading for Lebanon. Under the pressure of unfolding events, she was reassigned to Standing NATO Maritime Group 1 (SNMG1). "We need to send visible signs of deterrence and alliance solidarity," explained Mrs Möller. SNMG 1, whose area of operations extends from the Norwegian Sea to the Baltic, also included the German task force supply ship BERLIN as its flagship at the time. NATO's four floating task forces can be seen as the maritime equivalent of NATO's enhanced Forward Presence (eFP).
In line with unfolding events, Vice Admiral Jan C. Kaack, commander of the fleet, coined the slogan: "Not on our watch!" The German Navy had already begun to increase its activities in the Baltic and northern flank areas before the invasion commenced. For example, the frigate SACHSEN had been operating in the southern Baltic Sea since mid-February. With the help of its SMART-L surveillance radar, the navy was able to control the airspace over the Baltic Sea. "This is another signal of our alliance solidarity," Admiral Kaack remarked. Among the other measures that he initiated were occasional patrols by the P-3C ORION maritime patrol aircraft across the airspace of NATO's northern flank.

MDM: Your "Not on our watch!" made an impression at the beginning of the war in Ukraine, which has now been going on for several months. Specifically, what does this mean for the German Navy?

Vice Admiral Kaack: When I ordered the Navy on 24 February, "Everything that floats goes out," it was done with the sense of "Not on our watch!" And that's exactly the sentiment that the actions of the men and women of the Navy – on land, at sea and in the air – have impressively underscored in recent weeks.
As many as 28 units put to sea in a very short period of time. NATO Standing Task Forces were reinforced, and ships, boats and aircraft deployed to the eastern Baltic Sea. For our small navy, that's already an exceptional number. And this was achieved despite the shortage in personnel and materiel that plagues us all.
This was – and still is – a powerful stance on the part of our navy's personnel, demonstrating how firmly we support NATO's motto of "one for all and all for one!" Moreover, none of this has gone unnoticed by our friends, or by others. But let's also be honest - we can't keep up this number of units, this show of force, indefinitely. Nor was the focus here on the ongoing training of our units, but on a rapid response – on a visible sign of solidarity and determination to our allies and partners, especially those who feel particularly threatened because of their geographical proximity to Russia.
That is why we have created a new instrument from scratch with our "Baltic Guard" concept of operations. This enables us to coordinate activities (primarily) in the Baltic Sea whilst strengthening joint exercise activities. The operational concept has been passed up to NATO level in the Allied Maritime Command, so that our partners in the Baltic Sea can also participate. Even the US Navy has actively participated. In the meantime, NATO has declared "Baltic Guard" to be one of its "enhanced vigilant activities".

MDM: When you took office as "Inspekteur", you had already undertaken a tour

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Photo: Michael Nitz, Naval Press Service

Vice Admiral Kaack talking to MDM joint editor-in-chief Hans Uwe Mergener after the christening ceremony of the German Navy frigate KÖLN on 21 April 2022.

of the Navy. What did you learn that will be of consequence for deployments, NATO commitments, and the Navy's contribution in the Baltic Sea?

Vice Admiral Kaack: That is correct. Even then, the escalation of the security situation was becoming apparent. Today, our fears have become bitter reality. We must respond to this and make the Germany Navy "fit for the future". But success will depend on our will and our willingness to go down this path courageously and constructively. The Navy is going "all in" here, and we are leaving no stone unturned so that we become better and more capable.

However, it won't work without external help: The watchwords are: making deployments more flexible, adhering to certification standards as the basis for sending our men and women on deployments with responsibility, and significantly improving the approach to our units' maintenance.

This means taking a fresh look at deployments in the Mediterranean and making them more flexible or ending them. It also means accepting only a "combat ready" certification level as the basis for deploying our units. The Minister of Defence and the Chief of Defence Staff have given me the green light for this. In addition, the future of deployments is currently under discussion in the political arena.

Regarding our contribution to NATO, Commander MARCOM asked me the other day how we want to position ourselves in the future. My answer was simple: "The German Navy will stay regionally rooted and globally committed!" Regionally rooted – globally committed!

Our main area of operations will remain NATO's northern flank – the North Sea, the North Norwegian Sea and the Atlantic Ocean – and with a special focus on the Baltic Sea. This is what we are gearing up for in terms of equipment, training, command and exercise participation. Strengthening NATO task forces, participating in high-quality exercises and protecting carrier strike groups are in our interest.

A look at the Baltic Sea illustrates that this is now, unfortunately, once again a flashpoint on NATO's northern flank. It is heavily militarised and with a constant potential for NATO and EU forces to clash against their Russian counterparts. At the same time, the accession of Finland and Sweden to NATO, which we all very much welcome, is a strategic "game changer."

The German Navy is no small naval force in this region. We gladly accept the responsibility that this entails. Together with our partners in the Baltic Sea, we are currently strengthening our years of successful cooperation, also to make it clear to Mr. Putin: "Don't try it on us! We won't let you!" As a result of these activities, we are seeing "norm behaviour" on the other side: this is precisely because we are vigilant.

Photo: Bundeswehr/MFG 5

Aerial view of the future Warnemünde naval arsenal facility.

To consolidate our joint activities, the Chief of Defence recently proposed to NATO that the German Navy in Rostock establish a "Regional Maritime Headquarters for the Baltic" for our home region, where we are ready to take on this coordinating and leading role.

MDM: Does the €100Bn special fund announced by the government open up an opportunity for the Navy? What are your expectations?

Vice Admiral Kaack: In order to be able to continue to act as a reliable instrument of policy or, as we put it in the ‘Kompass Marine’ [1], as an instrument and arm of our state, we must "maintain and ... strengthen" our capacity. Ultimately, of course, this is about being better – together with our friends – than potential adversaries. Only then does the principle of deterrence work – when the outcome of a possible confrontation remains uncertain for the opponent.

This approach - to be better than others, together with friends - is our aspiration. To achieve this, however, the German Navy must be able to do one thing above all else, that is to function. We need our ships and aircraft to be operational now – not in ten years' time – and we must now bring the projects initiated in recent years to a successful conclusion.

In this context, the announcement of a comprehensive reform of structures, processes and procedures and the expected sustained financial backing for the Bundeswehr make me cautiously optimistic that we can achieve substantial improvements for the Navy. However, there is one thing that this €100Bn fund is not; a panacea for our problems. That is why we need to take two consistent steps.

First and foremost, we must strengthen our existing fleet. To this end, we have compiled and reported on a package of many small projects and requirements within a short period of time. Here lies the potential for short-term effects. In very simple terms, I put it this way: My seven priorities are: Ammunition, ammunition, ammunition, spare parts, spare parts, spare parts – and command capability.

A huge opportunity lies in the development of the new naval arsenal in Warnemünde. This substantial strengthening of our maintenance capabilities will enable a turnaround in the Navy's long-term operational capability. It is precisely this turnaround that the German Navy needs as soon as possible. With the purchase of the former shipyard site of MV-Werften, a start has now been made. The task now is to get the new outpost up and running quickly.

But we must also not lose sight now of the required modernisation of our fleet and, indeed, we will not. Here, we took the initiative early on and know very well what we need to do to keep up with the times and position ourselves for the future. Important steps – such as orders for the 212CD submarines and new fleet service boats, as well as procurement of the P-8 POSEIDON maritime reconnaissance aircraft – were already initiated before the "turn of the times".

Now we can look to invest in further strengthening our sub-hunting and strike capabilities, as well as finally acquire small combat boats for the Naval Special Forces Command and the “Sea Battalion” (naval infantry battalion). I see light at the end of the tunnel in the area of mine countermeasures as well as with respect to the replacement of tenders, auxiliary ships and tankers. And definitely long overdue is improving our command and control capability - from German Mission Network 2 and 4 to SATCOM and the upgrade of onboard networks [2]. At the same time, we want to move towards greater use of unmanned systems under and above water and in the air.

MDM: In addition to the acute present threats, the security agenda also includes over-the-horizon issues. How will the Navy


Photo: NVL

The K130 class corvettes are a significant system for the German Navy. Through the "Exceptional Budget for the Bundeswehr", it expects funding for five further members of the class. This third batch of ships would replace the five units of the first batch to provide a flotilla of ten ships with common equipment.

be able to balance ambitions as far afield as the Western Pacific with what is required on its own doorstep?

Vice Admiral Kaack: Regionally rooted and globally engaged - that is our claim and that is what policymakers can expect from us. At the same time, this means constantly balancing our existing forces and not losing sight of our main task.

The German Chancellor wrote some time ago: "To let Putin get away with this would mean allowing force to break the law without consequence. Then ultimately our own freedom and security would also be in danger." At the same time, he also said, the turning point of the times also acts like a burning glass globally. Diplomacy and solidarity with our valued partners must therefore be our vital interest - not only on our doorstep, but worldwide.

The German Navy can effectively support the foreign and security policy outlined by the Chancellor. We have already proven this with the Indo-Pacific deployment of the BAYERN. Sending just one grey ship to one of the world's most important maritime crisis regions has brought disproportionate foreign policy success. The German Navy is one of the most flexible and effective instruments of politics.

For 2024, policymakers have already decided that we will set a foreign policy focus on the Indo-Pacific and show presence together with our valued partners through deployment of a small task group, this time through the Panama Canal. Currently, we are in intense discussions with other friendly nations, such as the United States, Japan, France, and the Netherlands, on what we can do together to achieve the greatest training effects for our units.

MDM: Finland and Sweden are joining NATO. How will the Navy react to and assimilate the consequences?

Vice Admiral Kaack: As I have said elsewhere, Finland and Sweden joining NATO is a strategic "game changer." Friends become allies. What a story!

At this point, I want to strive for networks of relationships and friendships. All the naval heads of the Baltic Sea countries have known each other personally for years and have worked together to promote Baltic Sea cooperation. It is therefore not surprising that in this situation a simple phone call is enough to bring us together and support each other. I am very moved by this.

Strategically, the accession of Finland and Sweden to NATO opens up entirely new options with regard to supply lines for the Baltic. At the same time, the Alliance now has a greater incentive to ensure the freedom and security of the maritime lanes in and around the Baltic Sea. That's why I don't think much of the phrase that the Baltic Sea is now a NATO inland sea. That is already rather questionable under international law. We stand for the rules-based order. Peaceful passage and freedom of navigation on the high seas are part of this order. This also applies to the Baltic Sea.

MDM: DEUMARFOR is about to be certified and Full Operational Capability is scheduled for 2025. What is important about this for you?

Vice Admiral Kaack: The DEUMARFOR maritime command and control unit has just recently impressively demonstrated its initial capability in May. We will report this to NATO very soon. This brings us a big step closer to our goal of certification and thus full operational capability (FOC) at the right time.

As the German Navy, we want to assume responsibility - in the Alliance and in the Baltic Sea region. We have benefited from NATO's promise of security for decades. Now is the time to give back; above all to our friends in the Baltic States and Poland. We are establishing the aforementioned "Regional Maritime Headquarters for the Baltic" from existing structures. Basically, this HQ will take over the tasks currently performed by the Naval Command within the framework of "Baltic Guard": Coordinating allied forces in the Baltic region to ensure area-wide presence, vigilance and – of course – reconnaissance.

In addition, my 2022 intent sets three priorities:

- The Navy must become a powerful fighting force in preparation for what may come in the future. That means "frontline first," focusing everything on national and alliance defence, and demanding and promoting the will to win.
- We want to be responsible partners. That's why we want our allies to know what we stand for and where we take responsibility. We want to state this clearly in the Strategic Umbrella document, which we will of course derive from the German Government's National Security Strategy. Even now, I can say – with typically northern German reserve – that we have already made initial progress in both areas.
- In the end, however, the intact family is the soul and heart of any navy. With the Naval Compass, we have given ourselves a vision of how we want to be: Respectful, responsible, courageous and proactive. For me, these aspects are core elements of the necessary mutual trust that is the basis for successful cooperation and innovation, especially in a changing world.

What is particularly important to me? Some might say: Why does something always have to happen first before... Because politics is about balancing interests and compromise. Today, here and now, the correct political course has been quickly set. Now it is our turn. The support and appreciation of the population, which has known for decades that it can rely on us, I understand above all as an obligation to do everything for the protection and defence of our democracy, our values and our freedom.

The interview was conducted by Hans Uwe Mergener.

Notes

1. "Naval Compass" is a document that is intended to reinforce the German Navy's sense of identity: "It describes our identity – who we are and how we want to be. It serves as a personal navigation tool, showing us the direction of travel for the present and the future. It describes the demands and prospects of the navy to each and every individual."
2. The German Mission Network (GMN) is being developed by the German Armed Forces in order to support the harmonisation of command and control information systems and to improve interoperability in national and international missions.

Finland's Advantage:

All You Need to Know About Its Amphibious Assault Landing Craft

Marine Alutech designed and built Finland's amphibious assault landing craft. These are designed to be used for high-intensity war fighting and proved their excellent joint force interoperability (e.g. aboard a landing platform dock – LPD) during recent joint exercises with British, Dutch and US marines.

Since 1990s, these amphibious assault landing craft – like other assets used by the Finnish Defence Forces (i.e., Marine Alutech modular Watercat combat boats) – are purposely designed and equipped to engage and defeat foreign threats in northern as well as southern waters: arctics or tropics; in- and off-shore; for riverine to littoral tasks.

Finnish amphibious forces' capability development focus includes improving mobility and C3 systems for two decades. Marine Alutech and its Watercat® series of modular bespoke boats remain a crucial part of this progression.

Counting from its beginning, Marine Alutech has delivered more than 200 amphibious assault landing craft to the Finnish and Swedish navies and Finland's Coast Guard has 23 Watercat 1300 Patrol boats that operate under FRONTEX since 2013.

Using the advantages of modularity and versatility that optimise life cycle management and reduce ownership costs, Marine Alutech's amphibious assault/combat boats have predominantly the same systems and solutions as their other vessels, including:

- Advanced C3 & Navigation
- Ballistic & CBRN Protection
- Climate Controls
- Common Design Benefits
- Future Remote-Control and Autonomous Ability
- Interference-Protected Electronics (EMI/EMC)
- Light, Missile & Remote Weapon Systems
- Maintenance Service Level Agreements
- Propulsion Monitoring / Control (CANBUS)
- Reinforced Hulls for Icy conditions & Rough Beaching
- Surveillance & EO Systems

Marine Alutech's bespoke modular vessels and technologies are in accordance with Classifications, Standards and NATO Quality Assurance Requirements.

Finland's NATO ascension strengthens its defence capabilities and provides new opportunities for deeper cooperation and interoperability with partners. Marine Alutech's modular amphibious assault landing craft are based on successes with the Watercat® series. The M8, M12, M14 and M18 AMC are already NSN coded, interoperable with NATO forces and readily available.


Photo: Finnish Defence Forces


Photo: Finnish Defence Forces


Photo: Patria


Photo: Marine Alutech


Photo: Austrian Armed Forces

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India's First Indigenous Aircraft Carrier

Suman Sharma

By introducing its first indigenous aircraft carrier in its 75th year of independence, the Indian Navy is transitioning from being a buyer to a manufacturer.

India is inching ever closer to being a three carrier, blue water navy, with its first Indigenous Aircraft Carrier (IAC), which is also its biggest warship to date. Commissioned into the Indian Navy as Indian Naval Ship - INS VIKRANT ("Courageous" in Sanskrit), India, in its 75th year of independence, has been catapulted into the elite club of nations possessing the niche capability to indigenously design and construct an aircraft carrier. This is the Indian Navy's second aircraft carrier, after VIKRAMADITYA, purchased from Russia, was commissioned in 2013.

The 45,000-tonne warship, rechristened after independent India's first aircraft carrier – the VIKRANT, which played a key role in the 1971 Indo-Pak war – has a maximum speed of 28 knots and is much larger and advanced than her predecessor. Powered by four gas turbines producing 88 MW of power, the aircraft carrier, with her overall indigenous content around 76%, is touted as a perfect illustration of the nation's quest for "Aatma Nirbhar Bharat" (Self-Reliant India) which bolsters the Indian Government's "Make in India" initiative.

The Indian Navy has referred to "The reincarnation of Vikrant" as a "true testimony to the country's zeal and fervour in pursuing a capability build-up towards enhanced maritime security."

Project IAS is valued at close to US$3Bn at the time of its first sea trials. Fully designed by the Indian Navy's in-house Directorate of Naval Design (DND) and built by Cochin Shipyard Limited (CSL), in Kochi, this indigenous warship project has proceeded in phases, the first being the conclusion of the contract in 2007 between CSL and the Ministry of Defence (MoD). The warship's keel was laid in 2009, while the second phase was the carrier's launch in December 2014, followed by the third phase of the 262-metre-long ship's basin trials in October 2019. The final flight trials are expected to be completed by mid-2023.

Photo: Indian Navy

VIKRANT is the biggest asset in the inventory of the Indian Navy.

Former Indian Naval Chief, Adm (retd) Karambir Singh says, "An aircraft carrier's effectiveness is based on the aircraft it operates. To really make our two carriers effective, we need to quickly acquire fighters (RAFALE or F/A-18). Also, the case for an indigenous Twin Engine Deck Based Fighter (TEDBF) should be fast-tracked. As far as aircraft carrier construction is concerned, we can now build carriers in India. INS VIKRANT took a long time because of our decision to construct with indigenous steel and some delays by the Russian OEM. All that will not happen with the next one."

The Indian Navy is in the process of assessing the performance of the Boeing F/A-18 Block III SUPER HORNET and the French Dassault Aviation's RAFALE MARINE (M), both of which are pitted against each other for an order of 26 fighter jets to join the naval aviation fleet on board the IAC.

VIKRANT has been built with a high degree of automation for machinery operation, survivability and ship navigation, and has been designed to accommodate an assortment of fixed wing and rotary aircraft. She is capable of operating an air wing consisting of 30 aircraft comprising MIG-29K fighter jets, KAMOV-31, MH-60R multi-role helicopters, along with indigenously manufactured Advanced Light Helicopters (ALH) and Light Combat Aircraft (LCA) (Navy). Using Short Take-Off But Arrested Recovery (STOBAR), the IAC is equipped with a ski-jump for launching fighter jets, and a set of arrester wires for their onboard recovery.

Indigenous Content

VIKRANT has a large amount of indigenous equipment and machinery on board, from the major industrial houses of India, such as Bharat Electronics Limited (BEL), Bharat Heavy Electricals Limited (BHEL), Garden Reach Shipbuilders Limited (GRSE), Keltron, Kirloskar, Larsen & Toubro, Wartsila India, among others, as well as over a hundred Micro Small Medium Enterprises (MSMEs). Besides boosting the development of ancillary industries, this indigenous effort has also led to generating employment opportunities and bolstering a considerable return into the economy. A major spin-off is the de-

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Photo: Indian Navy

VIKRANT is to enter service in 2023.

velopment and production of indigenous warship grade steel for the carrier through a partnership between the Indian Navy, Defence Research and Development Organisation (DRDO) and Steel Authority of India (SAIL), which has enabled the country to become self-sufficient with respect to warship steel. Today all Indian warships constructed indigenously are manufactured using Indian steel.

Several design iterations, including use of 3D virtual reality models and advanced engineering software have been used by DND in shaping the carrier's design. CSL had also upgraded its shipbuilding infrastructure, as well as enhanced productivity skills during VIKRANT's construction.

The Indian Navy took delivery of VIKRANT from CSL following extensive user acceptance trials conducted between August 2021 and July 2022. During the trials, the ship's performance, including hull, main propulsion, PGD, auxiliary equipment, aviation facilities, weapons, sensors, as well as sea-keeping and manoeuvring capabilities were proven satisfactory in accordance with trial protocols and system parameters, thereby marking a historic milestone dedicated to two decades of hard work.

The commissioning of VIKRANT reinforces India's position in the Indian Ocean Region (IOR), as it realises its maritime aspirations.

Baltic Naval Procurement: Status Report

Conrad Waters

Whilst recent attention has inevitably been focused on events in Ukraine and the Black Sea region, the Russo-Ukrainian War also has profound implications for naval operations in the Baltic. Regional navies were already in the course of rebuilding capacity that had been allowed to degenerate in the post-Cold War environment when hostilities erupted. This process is now likely to accelerate as Western militaries respond to President Putin's "special military operation."

Sweden

The historically neutral Sweden is one of the countries whose security architecture has been most impacted by recent Russian aggression; a fact most clearly represented by the country's pending accession to NATO. The country is already in the course of a major programme of military revitalisation under the "Totalförsvaret" ("Total Defence") 2021–2025 regime that was approved by the Swedish parliament at the end of 2020. From a naval perspective, this has accelerated a process of reorientation towards Baltic defence after a period when a focus on international stabilisation missions had become a strong influence on maritime policy.

The most important aspect of Swedish naval recapitalisation has been the renewal of its underwater assets. This project dates back to the agreement of two linked contracts with Saab in 2015 that covered the upgrade of two of the three existing A19 GOTLAND class patrol submarines and the construction of two new-build vessels of the successor A26 BLEKINGE class. The GOTLAND class modernisation essentially ensures the continued operational relevance of the existing submarine flotilla whilst helping to rejuvenate relevant infrastructure and pave the way for technology intended for the new design. Key elements of the SEK 2.1Bn (circa US$195M) upgrade have included the insertion of a circa 2 metre hull plug to make space for additional equipment and installation of the latest Mk 4 iteration of the Stirling Air Independent Propulsion (AIP) plant. It also encompasses sensor and communications upgrades. The original contract was completed with the return of UPPLAND, the second boat to be modernised, to the Swedish Defence Materiel Administration (FMV) in December 2020. "Total Defence" 2021-2025 also mandated that the programme should be extended to the third member of the class, HALLAND, as part of a plan to increase the operational submarine flotilla to a total of five submarines. A SEK 1.1Bn (US$100M) contract was subsequently signed with Saab in March 2022 to undertake the necessary work.

Photo: Glenn Pettersson/Saab Kockums

Saab's upgrade of the existing GOTLAND class submarines is paving the way for delivery of the new BLEKINGE class. This picture shows UPPLAND on completion of her modernisation.

Photo: Peter Liander/Saab

The VISBY class corvettes – this is KARLSTAD – will commence a mid-life upgrade from 2024 onwards.

Construction of the new BLEKINGE class has been a task of a different order of magnitude. The contract signed in 2015 envisaged the two boats being delivered between 2022 and 2024 at a cost of SEK 7.6Bn (US$710M). However, Saab has struggled to meet both timescales and budget against a backdrop of significant challenges in revitalising design and construction capabilities that had been run down whilst the sector had been under the ownership of thyssenkrupp Marine Systems (tkMS). In August 2021, Saab announced that delivery of the two new submarines would be postponed to 2027 and 2028. Moreover, an additional SEK 5.2Bn (US$485M) had been allocated by the FMV to complete the project and for an (unspecified) expansion of the boats' capabilities. The delay probably accounts for the subsequent decision to extend the life of the 1980s-era, modified A17 class submarine SÖDERMANLAND by a further six years under a contract awarded in September 2022. However, tangible progress with BLEKINGE class construction is now being achieved. Notably, a formal keel laying ceremony involving the first two completed hull sections of the lead boat was held at Saab Kockums' Karlskrona yard on 30 June 2022.

The modernisation of Sweden's major surface combatants is following a generally similar trajectory to that adopted for its submarines. The most immediate priority is mid-life upgrade of the five existing VISBY class corvettes, which is anticipated to commence during the 2021-25 timeframe. In addition to enhancing existing capabilities, this will make good their current lack of a surface-to-air missile system and improve their electronic warfare capacity. Work is also underway in defining requirements for a "VISBY Generation 2" programme that will eventually replace the four units of the STOCKHOLM and GÄVLE classes on a one-for-one basis. These will draw heavily on technology specified for the VISBY modernisation and it is intended that the first pair will be in service by 2030. In the meantime, the current surface fleet will be bolstered by the return of GÄVLE and her sister SUNDSVALL to operational service after completing their own mid-life upgrades in the course of 2022.

The renewal of front-line submarines and warships is being replicated in investment in smaller and auxiliary vessels, including mid-life extensions to Mine Countermeasures Vessels (MCMVs) and progressive modernisation of the force of CB-90 series fast combat boats. An autonomous ENFORCER III variant of the latter type is currently undergoing trials. Other important programmes include those for the new TORPED 47 Saab Lightweight Torpedo (SLWT), a life-extension for the heavyweight TORPED 62 and the latest Mk IV GUNGNIR variant of the RBS15 anti-ship missile.

Looking further to the future, additional naval procurement will be driven by a new defence bill planned for 2023 that will, itself, be influenced by the aftermath of Sweden's September 2022 general election. It seems that a key naval priority is an increase in the submarine flotilla to six boats. This would most likely be achieved by acquisition of a third member of the BLEKINGE class. Saab is also undertaking research and development into a successor design – provisionally referred to as the UB-30 concept – that could eventually replace the existing GOTLAND type.

Finland

The backdrop to Finnish defence strategy is broadly similar to that of neighbouring Sweden. This includes the implementation of a "comprehensive" security policy focused on territorial defence and the shared decision to seek NATO membership in consequence of Russia's invasion of Ukraine. Naval procurement has also followed a similar course to that implemented by Sweden. This is seeing a wholesale renewal of the fleet's surface combatants through modernisation of the existing HAMINA class fast attack craft in conjunction with acquisition of new POHJANMAA class corvettes. Interestingly, much of the equipment used in both projects is of Swedish origin.

The POHJANMAA class will be the result of a "Squadron 2020" project that was devised to replace seven "legacy" vessels of different types with a quartet of larger and more capable warships. Displacing nearly 4,000 tonnes, the new corvettes will be the largest ships ever operated by Finland and have general-purpose characteristics that encompass anti-air, anti-surface and anti-submarine warfare. A €648M (US$650M) contract for the class's construction was signed with Rauma Marine Constructions in 2019 after considerable hesitation. The original plan envisaged the start of fabrication in 2022 and delivery of all four ships by 2028. Although many long-lead items have also been purchased, detailed design of the new ships has been delayed and construction has yet to start. Accordingly, the originally planned delivery dates now look increasingly optimistic.

The mid-life upgrade of the four HAMINA class vessels is closely linked to the "Squadron 2020" acquisition and is sometimes referred to as the "Squadron 2020 MLU". It shares much of the equipment specified for the new corvettes to ensure commonality across the fleet's frontline combatants but has a strong anti-submarine warfare emphasis. The project appears to have progressed relatively smoothly and was recently brought to a successful close with the return of PORI – the fourth and final vessel to go through the upgrade – in September 2022.

Although the modernisation of the fleet's surface combatants dominates procurement, a number of smaller acquisitions are underway. These include a series of nine, 21.5-tonne ÜTO class fast landing craft ordered from the local Kewatec shipyard. The first was delivered in August 2022 and all the remainder should be in service by 2024. A tender has also been launched to acquire replacements for the remaining KUHA and KIISKI class inshore minesweepers that date from the mid-1970s and are now overdue for withdrawal.

Photo: Finnish Navy

An early graphic of Finland's new POHJANMAA class corvettes. Completion of the long-awaited project by the 2028 target date looks increasingly challenging.

Denmark

Danish security policy is also changing as a result of the more hostile international

Photo: Conrad Waters

Lithuania has recently concluded arrangements to refurbish a further former British HUNT class MCMV. This photograph shows the ship – QUORN – during Royal Navy service.

environment. Defence spending will steadily increase to reach NATO's two percent of GDP target over the next decade whilst alignment with the rest of Europe will increase as a result of the favourable June 2022 referendum to join the European Union's defence policy. The post-Cold War environment saw the Royal Danish Navy de-emphasise its Baltic commitments to focus on the nation's more distant northern territories and ongoing global maritime trading interests. It seems likely that the additional funding that will be forthcoming under the new policy will support a rebalancing towards nearer seas.

Details of future naval procurement will only be forthcoming once the current "Defence Agreement 2018-2023" is superseded. This encompassed only modest investment in fleet capacity, most notably the long-delayed acquisition of a limited inventory of STANDARD SM-2 missiles to equip the three IVER HUITFELDT class frigates. However, it is already apparent that a major programme of fleet recapitalisation is now planned. In August 2022, Danish Minister of Defence Morten Bødskov stated that around DKK 40Bn (US$5.5Bn) would be invested in new warships over the coming years when announcing a new partnership with industry to maximise local involvement in the new plan. The lack of recent spending on naval construction means that much of the infrastructure used to build the current navy has now been lost. Accordingly, a key objective for the partnership is to identify how best indigenous shipbuilding capacity can be strengthened before the new phase of procurement gets underway.

Photo: Royal Danish Navy

The acquisition of STANDARD SM-2 Missiles, seen here being fired from the frigate NIELS JUEL during initial trials, has been one of the most significant recent investments in Danish fleet capacity. A much more significant programme of naval investment is planned.

The Baltic Republics

Although the Baltic Republics have held few illusions over the potential for Russian aggression, their naval capacity has remained modest. Maintenance of an effective mine countermeasures capacity has been a universal priority. As a result, small flotillas of modernised former British (Estonia and Lithuania) and Dutch (Latvia) minehunters form a focal point for all three fleets. The most recent development has been the July 2022 confirmation that Lithuania will bring a third modernised HUNT class mine-countermeasures vessel into operational service. The former Royal Navy QUORN will now be subject to a £55M (US$65M) upgrade at Harland & Wolff's Appledore shipyard before formal delivery in 2024. Meanwhile, October 2021 saw Estonia procure BLUE SPEAR surface-to-surface missiles from the IAI and ST Engineering Land Systems Proteus Advanced Systems joint venture. This might herald a wider rebalancing towards procurement of more offensive capabilities by the Baltic States.[1]

Poland

Current Polish defence policy was established under a Strategic Review initiated in 2016 and detailed in "The Defence Concept of the Republic of Poland" released the following year. The navy continues to be accorded a lower priority than the other armed services under this blueprint, being focused on the defence of the Polish coastline and southern Baltic. This relative lack of status has been reflected in limited headway with naval modernisation in recent years, with a number of programmes being progressively deferred. At this stage it is not clear to what extent the deterioration in relations with Russia will result in revisions to Poland's overall security architecture. However, the revised environment does, at least, hold out better prospects for existing procurement plans being realised. These are contained in a 2021-2035 Technical Modernisation Plan (TMP), which encompasses a number of significant naval acquisitions.

Although the modernisation of Poland's submarine flotilla remains a major priority for the TMP, difficulties in achieving an effective way forward means that it is renewal of the fleet's small force of major surface combatants that has now come to


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Photo: Babcock International

Babcock International's ARROWHEAD 140 design has been selected to meet the requirements of Poland's MIECZNIK (SWORDFISH) programme.

the fore. This is being implemented under the MIECZNIK (SWORDFISH) programme by the local PGZ-Miecznik consortium and has expanded from initial plans to build three corvette-sized vessels to a trio of much larger frigates. The project envisages the local construction of a licence-built design with appropriate technical support. In March 2022, it was announced that the United Kingdom-based Babcock International's ARROWHEAD 140 design had been selected over competing bids.[2] MBDA UK and Thales UK will also provide significant input in the areas of combat management, sensor and missile technologies. Subsequently, in September 2022, Babcock reported the signature of class design and transfer of skills contracts in preparation for the commencement of physical construction before the end of 2023. Current plans envisage the first ship being delivered during 2028 and project completion by 2031. Estimated programme cost as of mid-2021 was PLN 8Bn (US$1.7Bn).

Implementation of the MIECZNIK project undoubtedly represents a major challenge for Polish industry given that the only recent major warship to be built locally – the MEKO A-100 corvette ŚLAZĄK – took some 18 years to complete. However, the much better progress achieved by Remontowa Shipbuilding – an important member of the PGZ-Miecznik consortium – in delivering the trio of new Project 258 KORMORAN II MCMVs is promising for the new programme's success. ALBATROS – the second member of the KORMORAN II class – was delivered in August 2022 whilst the third vessel, MEWA, is currently in the final stages of sea trials. In June 2022, Poland's Ministry of National Defence signed a contract for a second batch of three of the type for delivery between 2026 and 2027. Reported cost is in the region of PLN 2.5Bn (US$525M).

In the longer term, the TMP also envisages the local construction of six light missile craft under the MURENA programme as well as the previously mentioned submarines. The latter project is known as the ORKA project and has struggled to gain traction despite the reduction in the current underwater fleet to the solitary elderly KILO class boat, ORZEŁ. Although various expedients such as the purchase or lease of second-hand submarines have been explored, a satisfactory conclusion to the planned purchase is likely to be delayed until the MIECZNIK programme is further advanced. Whether the expansion in Polish defence spending envisaged as a result of the Russo-Ukrainian conflict will help bolster the programme – which is eventually envisaged as encompassing three units – remains a matter of conjecture.

Photo: PGZ

Poland's indigenous KORMORAN class MCMV programme has been regarded as a significant success and a further batch of the ships has recently been ordered.

Germany

Amongst all of the European countries bordering the Baltic, it is arguably Germany that has seen the largest impact on security posture as a result of Vladimir Putin's Ukrainian "adventure". Its pledge to increase defence spending to meet NATO's target of two percent of GDP – supported by a special fund of €100Bn to be spent on military procurement – should go a long way to eliminating previous deficiencies and increase overall military, including naval, capacity. Given that the Baltic was typically accorded a relatively low priority in Germany's post-Cold War naval planning, it would be logical to assume it will now be a major beneficiary of the improved financial backdrop. However, as in many other European countries, there is a significant question as to whether a depleted industrial base will be able to adjust to the ramp up in expenditure that is now anticipated.

Indeed, Germany's naval renewal was already increasing the demands on shipyard capacity before the announcement of Chancellor Scholz's budget boost. As is the case for some of the region's other fleets, it has been the need to modernise underwater capabilities that has been amongst the most pressing procurement priorities. In July 2021, tkMS announced what it claimed was the largest contract in the company's history following signature of a €5.3Bn (US$5.3Bn) deal to build a total of six Type 212CD submarines for Germany and Norway. The circa 2,500-tonne (surface displacement) boats will have an overall length of 73 metres and are therefore significantly larger than previous iterations of the Type 212 series. They will also benefit from a range of technical enhancements. Four of the class will be delivered to Norway from 2029 onwards with two German boats being scheduled for acceptance in 2032 and 2034. The subsequent increase in defence funding makes it likely that the German Navy will acquire additional units. Various unconfirmed reports suggest that between two and four further submarines are planned. Given that tkMS

Advanced Integrated EW Suite to Secure the Naval Battlespace

The myriad threats to combatant surface fleets are incessantly evolving. If navies are to maneuver effectively and carry out their intended missions it is imperative that they counter all threats by achieving the ability to detect, track, engage and destroy them before they pose a danger. The protective bubble, which they must create around naval assets - battlespace - is of central importance to this effort. Modern navies require cutting edge tools that provide naval forces with effective countermeasures capable of mitigating the sophisticated threats to create the requisite battlespace.

To this end, Israel Aerospace Industries' (IAI) Group and Subsidiary, ELTA Systems Ltd., has leveraged its rich technological heritage and culture of innovation to field the **Scorpius family** of revolutionary and cutting-edge Electronic Warfare (EW) systems. Offering unmatched protection on Sea, **Scorpius-N** (EW AESA Naval System), at Land Scorpius-G (EW AESA Ground System) & Scorpius-T (Land Based EW-AESA Multi-Threat Emulator), and in the air Scorpius-SP (Self-Protection Active Phased Array Jammer Pod), the **Scorpius family** redefines the state of the art in EW and Electronic Attack system performance.

AESA and GaN – Game Changing Technologies

The Scorpius product range is based on ELTA's Active Electronic Scanning Array (AESA) technology. AESA, built with a staring array of wide-band solid state transceivers, provides a dramatic increase both in receiver sensitivity and in Effective Radiated Power (ERP) – far exceeding legacy EW solutions. Furthermore, AESA technology allows narrow multi-beam operation for reception and transmission, enabling the system to detect and target multiple threats simultaneously, across the entire field of regard.

The **Scorpius family** also incorporates the latest Gallium Nitrate (GaN) technology, which provides much higher power density and efficiency than previous generation Gallium Arsenide (GaAs) transistors, maximizing power and reducing energy consumption.
Leveraging AESA's exceptional sensitivity, the **Scorpius family** is able to detect and track advanced threats such as low probability-of-intercept (LPI) radars and long-range targets. Furthermore, with its superior ERP, Scorpius disrupts and degrades enemy radars with unparalleled effect. Scorpius effectively protects assets against modern airborne, shipborne and land-based threats, including fire-control radars, search radars, active missile seekers, and imaging radars.

Scorpius-N is ELTA's powerful shipborne EW suite combining advanced Electronic Countermeasures (ECM) and Electronic Support Measures (ESM) capabilities. It comprises four conformal antenna array panels, each housing transceiver arrays that cover a wide frequency range, a control unit for processing and managing operations, and an operator console that includes maintenance and training functions. **Scorpius-N** provides naval forces with the tools needed to contend with current and future threats.

Highly developed multi-beam, multi-technique power management capabilities enable **Scorpius-N** to efficiently jam multiple emitters, including all types of radars and RF missile seekers. The system detects and then tracks, engages and jams multiple threats over a wide geographic sector to create a protective hemisphere around naval forces. It will disrupt the operation of long-range, sea anti-ship skimming missiles before they close range and lock on to the vessel. Moreover, the system will effectively attack the newest generation low probability-of-intercept radar systems used to provide weapons with target data. Finally, **Scorpius-N** is fully compatible with leading hard-kill systems. In fact, its advanced capabilities significantly reduce the burden on hard-kill systems, preserving their capabilities for further engagement.

Images: IAI ELTA

Scorpius-N employs ELTA's "Intelligent ESM" technology to generate an automatic Electronic Order of Battle (EOB), including emitter classification, and deliver a comprehensive situational awareness picture of the electromagnetic environment. It also supports radio-silent operation by providing an Emission Control (EMCON) mode, whereby the ship enters a fully passive mode for situational awareness.

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also has additional export commitments, it seems that the capacity of its Kiel yard may be inadequate for the task ahead. One consequence has been the German shipbuilder's purchase of the defunct MV Werften shipyard in Wismar; a previous casualty of the pandemic-related collapse in cruise liner orders. This will, presumably, require a significant effort retraining the existing workforce in the skills required for the specialised art of submarine construction.

Another existing construction contract that has considerable relevance to the Baltic is that for the second batch of five K130 BRAUNSCHWEIG class corvettes awarded to the ARGE K130 consortium in September 2017. The corvettes are being constructed in half sections at consortium shipyards before being integrated at NVL's Blohm & Voss facility. They include a series of incremental but cumulatively material enhancements over the first batch. KÖLN, lead ship of the new series, was christened at the Hamburg yard in April 2022 and is now running sea trials. However, delays with the combat management system due to be fitted to the class could impact the operational debut of earlier members of the batch by up to two years. The type's construction was initially seen as maintaining production capacity in advance of construction of the new F126 class (formerly MKS-180) frigates, on which physical work is expected to begin in 2023. However, the availability of additional funding has resulted in speculation that a third batch of corvettes of similar specification to KÖLN and her sisters will also be ordered. This would provide commonality across the class whilst allowing the older ships to be transferred to friendly fleets.

Photo: German Armed Forces

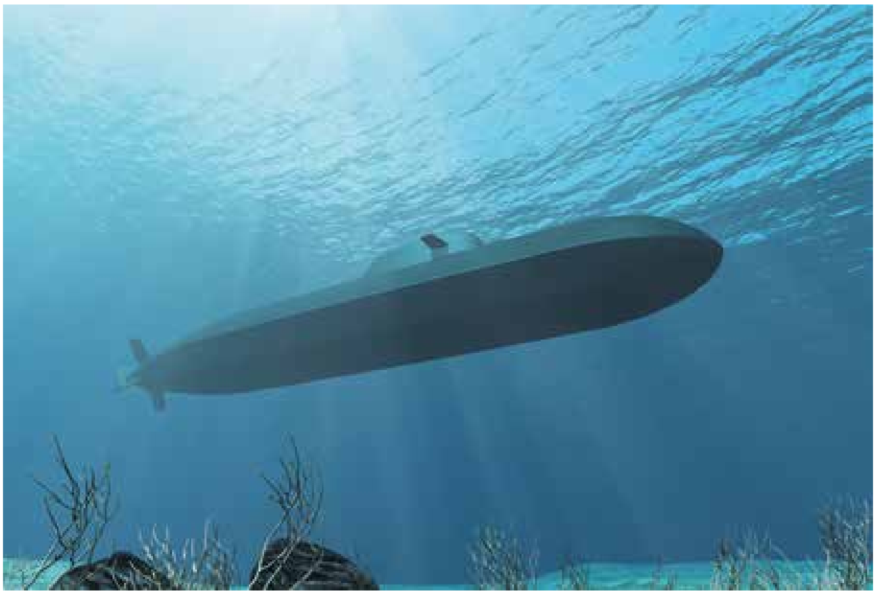
Continued construction of Germany's K130 BRAUNSCHWEIG class corvettes – OLDENBURG is seen here – could result in older members of the type being sold for overseas service.

The much bigger F126 class vessels are largely intended for "blue water" operation and – unlike the most recent F125 BADEN-WÜRTTEMBERG "stabilisation" frigates are configured for high intensity warfare. The current agreement with lead contractor Damen encompasses a firm commitment for four ships but the improved budgetary outlook makes it more likely that options for two additional ships will eventually be exercised. Replacement of the existing F124 SACHSEN class air defence frigates under a joint project with the Netherlands is envisaged in the longer term.

Other current naval procurement includes two Type 707 replenishment oilers and three replacement Type 724 intelligence gathering ships. Although all have been contracted to NVL, much of the physical construction work on the tankers will be allocated to Meyer's Neptun yard at Rostock. In addition, two new experimentation and support vessels are being acquired from Fassmer. All these ships replace existing vessels on a numerical like-for-like basis. The Naval Aviation Command is also benefiting from major new acquisitions, most notably of P-8A POSEIDON maritime patrol aircraft and NH90 SEA TIGER sea control helicopters to replace legacy ORION and LYNX types.

In addition to the programmes referenced above, it would seem likely that Germany's increased defence budget will allow additional projects to be pursued. For example, the amphibious Sea Battalion has a longstanding requirement for high speed landing craft that might now finally be realised. Further into the future, the Type 404 ELBE class fleet support ships will also fall due for retirement towards the end of the decade, likely adding further pressure to the stretched defence industrial base.

Photo: tkMS



The signature of a €5.3Bn contract to build six Type 212CD submarines for Germany and Norway is reportedly the largest deal in tkMS's history.

Notes

1. Robert Czulda provided a more comprehensive review of the modernisation plans being taken forward by the Baltic Republics in the June 2022 edition of MDM.

2. Based on the Danish IVER HUITFELDT class hull, the ARROWHEAD 140 is the export variant of the British Royal Navy's Type 31 frigate design.

BZM evo – a Fuel Cell Concept for Future Submarine Applications

Comparative studies of various Air Independent Propulsion (AIP) systems such as STIRLING engines, closed cycle diesel and steam turbine systems in conventional (non-nuclear) submarines have demonstrated the clear superiority of fuel cells over combustion-based technologies. The Proton-Exchange Membrane (PEM) fuel cell was selected to provide a new generation of submarines with an AIP system providing previously unattainable performance in terms of submerged endurance and acoustic performance.

Fig. 1: The BZM34 fuel cell module

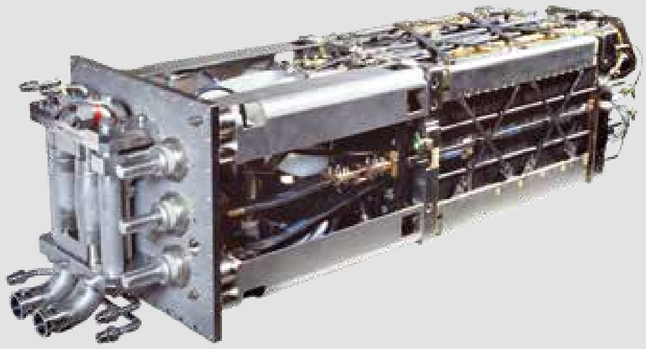


Fig. 2: The BZM120 fuel cell module

Photos: Siemens Energy

For automotive applications, fuel cells have been well-known for decades. Derived from these applications, for which Siemens (today Siemens Energy) had common activities with Germany's largest car manufacturer Volkswagen, Siemens started developing fuel cell systems for AIP application. Partners in this project were the German Navy in cooperation with the Italian Navy and HDW (formerly Howaldtswerke Deutsche Werft – now ThyssenKrupp Marine Systems (TKMS). Their development was started with the aim of supporting the new U212A class design, for which Siemens contributed not only the fuel cell system but also the propulsion motor, the unique PERMASYN drive. In 2003 the first class 212A AIP submarine started operation.
Since then, after more than 20 years from the beginning of the first development, Siemens Energy has supplied AIP fuel cell systems for nearly 40 submarines of different classes (209, U212A, 214, 218 and DOLPHIN) with a total installed power of more than 10 MW. Continuous feedback from the crews of AIP submarines which use Siemens Energy's fuel cell modules has been extremely helpful for the optimisation of the fuel cell plant.
Based on this feedback and the success of the first generation of fuel cell modules, the BZM 34 (Fig 1) and the BZM 120 (Fig. 2), Siemens Energy Energy believes that it is the right time for its next innovation. The obvious advantages of both module types, such as high efficiency and a redundant plant concept, are combined into the new development designated BZM evo. Additional objectives of the development include the optimisation of power density, significant reduction in weight and costs and new installation concepts supporting high availability.

BZM evo

The BZM evo design's features (Fig. 3) are based on the preceding BZMs. The BZM evo will still use the cascaded concept, whereby most of the process media are consumed and only traces of residual gases are released. Without the need to recycle media that is seen in alternative AIP concepts, the BZM evo provides an optimal volume and a reduced signature due to the absence of recycling blowers.The humidification of the media is performed inside the module by utilising the product water. For this feature an extra section, the humidifier section, is integrated into the stack. Most of the balance of plant components are still an integrated part of the module and are located between the stack and the outer endplate. Quick couplings as interface for media and electricity can be identified on the outer end plate. They enable the fast replacement of modules (plug & play).
The former modules were quite heavy, and it was somewhat difficult to move them through a submarine. In response to a specific user request, we were able to reduce the weight to less than 200 kg. This simplifies the transport and installation of the BZM evo.
The power density is somewhere in the middle of the related data of the former BZMs, while the efficiency targets are in the range between 55 – 70% (depending on applied load). Improved components allow a significant volume reduction in comparison with the former BZM 34. The scalability of the module's power is another feature which was considered during the development of the BZM evo. The power of the BZM evo covers a wide range from 5 kW up to 60 kW. For a submarine's AIP's power supply 40 kW was selected as the design point. Smaller modules with reduced power allow integration into Unmanned Underwater Vehicles (UUVs) which might achieve higher importance in the future.
In contrast to the previous generation of fuel cells, where all signals were individually transferred to A/D converters in separate cabinets, signal conversion now takes place within the module itself and the digital signals are transferred by databus to the control units. This … significantly, since some of the integrated cabinets used for data conversions are no longer needed.
Another feature of the new concept is the direct link of each BZM evo to the grid by converting the module's voltage to the required grid voltage by an integrated DC/DC converter. Future AIP power plants consisting of eight to twelve single power units

(BZM evo & DC/DC converter) will feed a maximum power of up to 320 – 480 kW into the grid without exceeding the footprint of an existing BZM34 (or BZM120) plant. For greater power (between 320 and 480 kW) the DC/DC converter can be integrated with the former AD converter cabinets.

Fig. 3: The new BZM evo

Amongst the key advantages the BZM evo provides compared to the previous BZMs are:

- A reduction in the weight of a single module down to a level where it can be easily carried through a submarine (the targeted weight is << 200kg per module in comparison to earlier BZMs, where the weight was in a range of >> 600 kg).
- In contrast to the BZM 34 the volume of the BZM evo is reduced to nearly 50%, while the power of the module is increased by nearly 15%. This is a huge increase in power density per module.

System Architecture and Operation

The new system concepts comprise a power unit combining a single BZM evo and a single DC/DC converter. This combination is accompanied by a number of advantages, such as:

- Load management according to required power
- Optimising efficiency and H2-consumption (extends mission duration)
- Allows different individual operation set-points of each BZM evo according to its lifetime (along with a smart BZM monitoring system)
- Allows the integration of spare parts (BZMs and DC/DC converter)
- Rapid plug and play replacement of a defective BZM by on-board stored spare modules in less than 5 hours
- Increase in power density by approx. 15% (in comparison with BZM 34 installations)
- Integration of complete systems into new constructions and retrofits.

In terms of dimensions, the intention is to remain within the footprint of the former BZM 34 installation, where eight small water cooled DC/DC converters are integrated in the same fixture as the eight BZM evos. Easy coupling of media and power leads allows for the fast replacement of the modules for maintenance. In total the availability of provided power is improved as well as the degradation options. The new concept fosters the availability of the AIP plant in three ways:

- Increasing the degradation rate of the entire fuel cell plant since single modules feed into the grid and losses of single modules do not jeopardise the loss of the complete power supply
- The optional integration of backup modules, increasing redundancy within the plant
- Easy replacement of defect modules by fresh spare modules, in case spare modules are available on board (non-integrated spare modules).

Regarding degradation, single units can be switched off and in case of a larger impact the power supply can be established down to a single module finally, which still provides electrical energy. Considering these facts, the supply of electrical energy to the onboard power grid is more reliable and flexible than with previous systems.

Future Applications

Unmanned Underwater Vehicles

In addition to the current employment of fuel cells in AIP-equipped submarines as a well-established solution, there is also a clear trend towards the future use of UUVs as at least a partial replacement of conventionally-manned submarines. In comparision to a conventional AIP-equipped submarine the costs of a UUVs are significantly lower and should reach approx. the range of 1-5% of AIP-submarine costs. But due to size limitations, a UUV's mission profile might be limited by the amount of stored energy in the form of fuel and/or batteries. Batteries implicate low power density and loss of energy by self-discharge. Therefore, Battery driven UUVs suffer from very poor operational radius. Diesel generators have been optimised to overcome this disadvantage and they can be integrated into a battery/generator hybrid. The battery provides energy while the UUV remains submerged. Once discharged, the diesel generator recharges the battery. Although the diesel generator allows the UUV's operational radius to be extended a significant drawback of this concept relates to the frequent recharge events, for which the UUV must approach the surface for snorkling and loose its acoustical and optical camouflage. The noise of the diesel generator and the visibility of the UUV allows easy identification of such vehicles.

This state of affairs improves dramatically when - instead of diesel generators - fuel cells are used to provide the UUV's power. The UUV can always remain in a submerged state and its signature is radically reduced. During periods of high power demand, typical during transit activities, the fuel cell supplies its power directly to the propulsion system. In periods of low power demand, typical for a state of hibernation, the battery takes over the power supply and is recharged by the fuel cell, once the charging level of the battery gets low. The huge advantage of this setup is that the UUV can remain on spot and does not need to rise to the surface to recharge its battery. The operation of fuel cell system happens in complete silence.

From the very beginning of the development of the BZM evo series, both applications, the integration into an AIP-equipped submarine on the one hand and the power supply of a UUV on the other hand, have featured equally in the requirement specification. For UUV-applications, the specification was not limited to the fuel cell module. It included all relevant balance of plant components, such as media storages and management, the DC/DC converter for the interface with the grid, the hybrid battery, etc.. Embedded process control and system automation allow autonomous operation of the energy supply. The energy concept is based on a hybrid architecture considering both the fuel modules and the batteries. For achieving optimal power supply for a specific hull design, the proposed power solution is a result of evaluating a customer's load profiles on the one hand and managing physical limitations, e.g. available space, on the other hand.

Fig. 4: Live demonstration running certain mission profiles

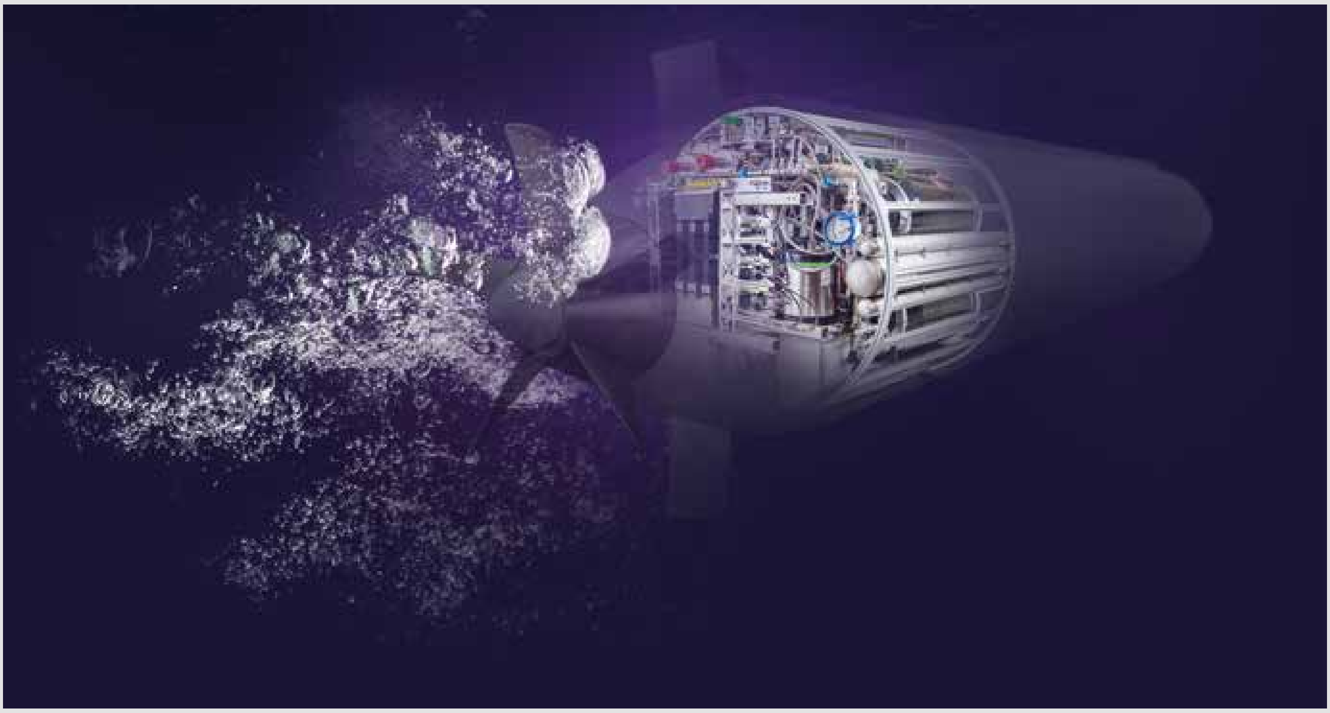


Fig. 5: Siemens Energy's land-based demonstrator inside a UUV application

Initial system tests were performed with a Land-Based-Demonstrator (LBD) at the Colorado State University (US) in 2018 and completely lived up to expectations. (Fig. 4). The required media, pure oxygen and pure hydrogen, are stored on-board on-board a UUV either in a liquefied or in a compressed state. From the storage the media are released at an appropriate pressure level to the fuel cell and do not require additional compression. Due to the exceptional cascaded concept of the fuel cell modules the relief of unused process gases is limited to a minimum, which can be handled within the hull of the UUV.
The power output of such a system can be tailored towards customers' demands within a range starting from a few kWs up to 60 kW as an upper limit. Module sizes, primarily depending on membrane size, can be adapted to fit into almost any diameter of vehicle shape. Siemens Energy now offers a complete "energy pack" which is ready for its integration into an UUV (schematically displayed in Fig. 5).
Interconnected with this topic Siemens Energy has started research activities on fuel storage concepts. A wide raqnge of different fuels such as methanol, metal hydrides and others are considered as energy carriers. Their conversion into electrical energy will allow an increase in the energy density of the whole fuel cell system. Specifically for UUVs it permits operation in smaller hulls, which requires very low power levels (0.1 ….1… 5 kW).

Air-Independent Emergency Propulsion
Another application is Air-Independent Emergency Propulsion (AIEP). Here, the idea is to replace conventional diesel engine driven generators in new nuclear-powered general-purpose attack submarines (SSN) by incorporating fuel cell systems. This might also be available as a retrofit solution within the current SSN fleet.
The drivers for considering fuel cell technology are the same advantages as already stated above. Especially the avoidance of visibility during snorkling and the noise created during diesel generator operation are exceptional advantages which favour the integration of fuel cell solutions. The ability of fuel cell technology to create the lowest level signatures compared with its competitors should certainly make it a contender during concept evaluations.

Conclusion

The introduction of hydrogen as a fuel for energy storage has achieved a wide level of acceptance. Several applications within industrial, automotive and energy sectors are expecting huge growth. In the military sector, especially in the field of submarine power supply, the advantages provided by AIP installations allow conventional submarines to undertake longer missions than those typically associated with their traditional diesel-electric counterparts. As well as their underwater mission endurance, AIP also provides advantages such as reliability, air independence, low signature applicable to SSK, SSN and UUV applications.
The new BZM evo fuel cell module is a further enhanced system from the family of Siemens Energy fuels cells that is now in its fourth generation after already being used aboard the German submarine FGS U1, the HDW U212A class, the tkMS 214 class, the DOLPHIN AIP-equipped boats and others.
The development of the BZM evo has resulted in some significant advantages compared to its predecessors. These include a reduction in volume of nearly 50% and an increase in the power of each module by nearly 15%, resulting in excellent power density per module. The advances achieved with respect to weight reduction, efficiency and H2 consumption have extended mission duration. The concept also demonstrates improvements in user-friendliness by allowing for rapid plug and play replacement of a defective BZM evo module in less than five hours by spare modules stored on board. Further focus was placed on reducing the degradation rate of the entire fuel cell plant by the combination of single fuel cell modules with their own DC/DC converter connected to the submarine's grid.
Siemens Energy is confident that the BZM evo will develop a firm place in the market, both aboard conventionally manned submarines and on future applications such as UUVs. It is designed to meet the requirements for both new systems and retrofits of older AIP plants. It will soon be commercially available for all platforms, including UUVs.

Strategic Competition in the Arctic

Scott Savitz

The Arctic's strategic significance has been largely overlooked since the closing days of the Cold War. As that confrontation subsided into history, militaries across NATO shifted their focus to new battlefields, allowing the Arctic to fall off the top of the map. However, emerging geopolitical dynamics and the changing physical environment of the Arctic are both contributing to its increased strategic importance. In this article, we begin by briefly characterising the Arctic and its military significance, followed by a brief review of its military history. We then explore key drivers behind today's strategic competition in the Arctic, and how different nations are approaching that competition. Finally, we present some closing remarks and integrated insights.

The Arctic is most commonly defined as the territory north of the Arctic Circle (66.5°N), covering an area twice the size of Europe, though some definitions of the region also include adjoining territories.[1] It can be readily divided into three sub-regions – the European Arctic, the Siberian Arctic, and the North American Arctic – based on both the physical environment and political considerations. At any given latitude, the European Arctic is generally the warmest of the three, while the North American Arctic is usually the coldest. The milder conditions of the European Arctic make it more accessible to maritime traffic than other sub-regions, and have also contributed to it having most of the Arctic's population.

Photo: US Navy

The LOS ANGELES class attack submarine PASADENA (SSN-752) pictured in the Beaufort Sea during Ice Exercise 2022. Emerging geopolitical dynamics and the changing physical environment of the Arctic are both contributing to its increased strategic importance.

Characterising the Arctic and its Military Significance

Three key factors define the Arctic's geography from a military perspective. The first is that its harsh climate batters both people and machines in ways that affect every aspect of military operations. Unless systems have been expressly designed to work in Arctic conditions, or have been hardened for that purpose, they are unlikely to work. During much of the year in the Arctic, systems designed for more benign environments fail: lubricants freeze, fuels gel, parts become brittle, batteries fail, engines often do not start, and fierce winds break off protruding pieces of equipment. Electromagnetic communication is hindered by the deflection of solar radiation to the polar regions, which interferes with human-generated signals. Seemingly trivial procedures, such as putting up tents or providing water supplies, need to be revised when the ground is almost impenetrable and water freezes in seconds. Ice builds up on exposed surfaces and equipment, thickening to the point that it can destabilise ships, and requires continual removal (often by manually striking it with wooden implements). Movement on land is impeded both by intensely slippery ice in winter and by thick, muddy mire in summer.

The Arctic environment's effects on humans are also profound; people need to struggle continually to survive, let alone to conduct operations. Their efficiency is impaired by intense cold that requires short work/rest cycles, disrupted circadian rhythms due to months-long periods of darkness and light, the struggle to operate machinery despite howling winds, and thick swarms of mosquitoes and other biting insects during the summer. In winter, their mobility, manual dexterity, and hearing are impaired by lay-

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ers of thick clothing. Bare skin burns on contact with metal at Arctic winter temperatures, so even the most delicate operations still require thin glove liners. Depending on the season, their visual acuity can be diminished by protracted darkness or snow blindness. Rough northern seas jostle ships in ways that are hard on sailors, while icebreaker crews are subjected to intense shuddering motions as they crash through thick polar ice. Ice conditions can vary with limited predictability, and even limited ice concentrations can pose a threat to ships that are not designed for polar environments. For all of these reasons, Arctic-specific training, equipment, and platforms are required to enable personnel to work effectively in the region, and to limit the frequency of injuries. Any injuries that do occur – due to the environment, accidents, or enemy action – will necessitate medical treatment in shelters that are far warmer than the ambient environment for much of the year, regardless of the difficulty of achieving such conditions.

A second factor shaping military operations in the Arctic is the dire scarcity of infrastructure. Transportation networks are sparse, as are facilities to provide medical, maintenance, or logistical support (or even basic shelter). The scarcity of ports that can provide safe havens for vessels exacerbates the challenges of maritime movements. Despite reduced maritime ice cover during the summer due to climate change, ice remains a formidable threat for most of the year, complemented by rough seas. Arctic communications are hampered both by a paucity of satellites in polar orbits and by limited ground-based or maritime communications infrastructure, as well as the previously mentioned deflection of solar radiation. Physical infrastructure in the Arctic is continually degraded by the extreme environment. This includes not only low temperatures, intense winds, and storms, but also uniquely Arctic challenges such as thawing permafrost and icebergs that gouge underwater infrastructure. This infrastructure needs to overcome the Arctic's dual "tyranny of distance," namely its vastness and its remoteness from the rest of the world. A couple of examples indicate how remote parts of the Arctic are, even from sub-Arctic areas. The distance between Greenland's northern and southern extremities is the same as that between Oslo and Tunis. A ship operating off the north-central coast of Alaska is over 1,000 km away by air from the more populated southern part of the state, and over 2,000 km away by sea from the nearest US maritime base at Dutch Harbor (which is also the closest US port of any appreciable size).

Photos: US Navy

A defining aspect of Arctic operations is the extreme conditions that batter both people and machines. These tranquil views of the US Navy's Ice Camp Queenfish – temporarily established on a floating ice sheet during a 2022 Arctic exercise – provide little indication of the harsh climate that can be experienced.

The third factor shaping Arctic military operations is the pattern of interspersion of land and sea. While the central Arctic Ocean is relatively open, the region is ringed by lands that create a series of maritime chokepoints that can be used to detect, track, and target vessels. The Bering Strait, for example, is only about 85 km wide, and contains US and Russian islands that are only 4 km apart. The Greenland-Iceland-United Kingdom (GIUK) Gap is wider, at just over 1,000 km, but also represents an island-fringed chokepoint that can be and has been used to track movements from Arctic waters into the North Atlantic. While key routes within the Arctic – the Northwest Passage (via Canada) and the Northern Sea Route (via Russia) – are becoming more available due to reduced seasonal ice cover, they remain somewhat risky due to a combination of residual ice, shallow waters that are not always well-charted, and limited support infrastructure ashore. Russia has invested heavily in icebreaker capacity and infrastructure along the Northern Sea Route in recent years to support both commercial and military traffic; this may give it an advantage in the speed with which it can redeploy ships to or through the Arctic.

The History of Conflict in the Arctic

The Arctic has experienced human conflict for centuries, often driven by competition for its maritime resources. However, those were generally small-scale fights that did not involve national militaries. Examples include episodic conflicts between Inuit and Norse settlers in Greenland, or among various nations' whaling fleets in the remote Svalbard archipelago, 800 km north of mainland Norway. There have been a few Arctic conflicts involving national military forces in recent centuries, all involving battles among the Nordic nations and Russia, plus a British attack on Arctic Russia during the nineteenth century Crimean War. However, the Arctic first became an arena of large-scale conflict during the Second World War. There was substantial Arctic fighting during the German invasion and occupation of Norway, extending as far north as Svalbard. Finnish and German forces also fought the Soviets in the Arctic northernmost reaches of mainland Europe. To the north of those battles, British and American convoys resupplying the Soviets had to fend off German attacks from occupied Norway. In addition, British and American forces occupied Greenland and Iceland, both parts of the Kingdom of Denmark. This was partly to prevent them from falling into German hands, and partly to use them as bases to counter German submarines and conduct other operations across the Atlantic.

The Cold War transformed the Arctic into a central fulcrum of tensions. Paradoxically, this remote region is the shortest air route between Eurasia and North America, making it a vital battleground once aircraft and missiles had sufficient range to cross it. Thick ice cover and the continual grinding sounds of ice sheets also made the Arctic an excellent place for submarines to hide, once they had the requisite endurance and durability. Copious Soviet naval power was concentrated in the Kola Peninsula, in Russia's northwest, where it remains. To prevent submarines based there from reaching the North Atlantic, the NATO alliance closely watched the previously mentioned GIUK Gap at the Arctic's southern edge.

Photo; Torbjørn Kjosvold/Norwegian Armed Forces

A P8-A Poseidon maritime patrol aircraft pictured at a Norwegian Air Base during the Cold Response 2022 exercise. Arctic conditions challenge military equipment to its limits.

Further north, the US Air Force established and operated from Thule Air Base in northern Greenland. NATO nations adjoined the Soviet Union on opposite sides of the Arctic, namely the Norwegian-Soviet land border and the Bering Strait. Throughout the vastness of the Arctic, both sides closely observed and challenged one another in an effort to gain military advantage.

The Drivers of Arctic Competition Today

The collapse of the Soviet Union led to a dramatic decline in military interest in the Arctic. Russia's economic and military weakness caused it to close some Arctic bases, while NATO militaries focused on the Balkans, Afghanistan, the Sahel, and Iraq. However, over the last 15 years, the Arctic has become a renewed theatre of military competition, due to four main drivers. The first is Russia's military reawakening and its belligerence at lower latitudes. Russia has reopened many of the Arctic bases that it had closed during the 1990s, and has increased the extent of its Arctic military activities. Russia is also particularly keen on military activity in the Arctic for symbolic reasons, linking the Arctic to Russia's identity. Top Russian officials have referred to the Arctic as Russia's "Mecca," and a large fraction of Russia's economy is based on Arctic fossil fuels and minerals. The Arctic has also been an environment in which Russia can make large maritime claims with limited fears of repercussions. When a Russian submarine planted a flag under the North Pole in 2007, this was perceived in Russia and elsewhere as an unwarranted assertion of sovereignty, but without further escalation.

NATO nations and partners within the Arctic have been stimulated by growing concerns about Russian threats in the region, expanding their Arctic training and exercises well before the Russian invasion of Ukraine. Rotational forces from Britain, the Netherlands, and the United States have been regularly operating in northern Norway for years. Exercise Trident Juncture 2018, held in sub-Arctic and Arctic regions of Norway, was NATO's largest exercise in nearly two decades. In recent years, NATO Arctic nations Denmark, Norway, and Canada have updated their Arctic strategies and other documents to more explicitly recognise the need to counter Russian threats and secure their sovereignty in the far north. All three face chronic chal-

Photo: US Navy

The Arctic's lack of infrastructure and its remoteness have a significant impact on the conduct of military operations in the region. Here a Canadian CC-138 TWIN OTTER STOL utility aircraft departs for an Arctic operation.


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lenges to secure their sovereign territory against aerial or maritime intrusions, or even to achieve full awareness of activity there. Canada's and Denmark's immense Arctic territories are thousands of kilometres from their main population centres; in Denmark's case, it is a nation of 5.8 million people attempting to achieve security around Greenland, an island half the size of the entire European Union. Norway is another small country with sovereignty over far-flung Arctic islands, including Svalbard, in which it is treaty-bound not to station any military forces.

In recent years, non-Arctic NATO nations – notably Britain and the United States – have also published Arctic strategies that called for more focus on countering a newly aggressive Russia. The United States did so not only at a national level, but also developed Arctic strategies for individual departments and services, reflecting the need to counter an increasing Russian challenge. Sweden and Finland, despite declining to join NATO until 2022, had previously published strategic documents that highlighted plans to counter Russian threats in the Arctic more assertively. The imminent addition of Sweden and Finland to the NATO alliance will increase NATO's Arctic capabilities, since both nations have extensive experience in conducting Arctic operations, as well as valuable facilities and transportation networks. While both nations have relatively small populations and militaries, they are well-equipped and well-trained for operating effectively in this environment.

Overall, as Russian-NATO tensions rise, the geographic fundamentals of the Cold War are re-emerging. The Arctic remains the shortest route between Russia and North America, a place where Russian naval forces are concentrated, and a key environment for both submarine operations and countermeasures against them. It is also an area where NATO nations border Russia, even more so than during the Cold War: Finland's long Arctic border with Russia will create new areas of Arctic contact between Russia and the alliance.

Photo: Crown Copyright 2020

NATO nations and partners within the Arctic have been stimulated by growing concerns about Russian threats in the region. This photograph shows NATO warships operating together during training off Iceland.

Beyond Russia, a second, lesser driver of Arctic competition is growing Chinese interest in the region. Although China lacks Arctic territory, Chinese officials have argued that their country should play a central role in the Arctic, justifying this by referring to China as a "near-Arctic state" or by claiming that the Arctic should be a shared global commons. Much of China's interest in the Arctic is commercial, as it seeks additional sources of raw materials and aims to create a "Polar Silk Road" that facilitates intercontinental shipping. China also seeks diplomatic and scientific prestige associated with the Arctic. It fought hard to become an observer at the Arctic Council, a body whose only full members are Arctic nations. Chinese scientists conduct Arctic research on Svalbard, as well as aboard China's two XUE LONG (SNOW DRAGON) icebreakers. Chinese research activity in the Arctic could potentially have military benefits, providing China with knowledge of the polar environment in ways that facilitate future submarine operations, or skills to facilitate intelligence collection in the area. Other Arctic nations have been concerned about China's growing involvement in the region, though this is far less vexing than Russia's palpable threat.

The third driver of competition is the Arctic region's changing accessibility, due to climate change and technological advances. Not only is total ice cover declining substantially during the warmer months of the year, but the thickness of the ice that remains is also reduced. The result is that more surface warships are able to operate in more portions of the Arctic at lower risk than before, contributing to competition. At the same time, the increasing capabilities and falling costs of satellites and other un-crewed vehicles are also making the region more accessible, collecting increasing volumes of data from space to the seafloor in ways that can facilitate other military activity. A countervailing effect is the increasingly rapid degradation of infrastructure on land: roads, equipment, and buildings are being damaged by thawing permafrost, coastal erosion, and more extreme storms. This fosters a different type of military competition in the Arctic, namely relative investments in resilient ground-based infrastructure and repairs.

The final driver of Arctic competition is the rush for resources. The world hungers for large quantities of minerals, fossil fuels, and fish, all of which are abundant in the Arctic. Unlike in many areas of the world, a desire for resources has not resulted in disputes over land: as of late 2022, none of the Arctic's land area is disputed. There are a couple of dormant disputes over mari-

Photo: Crown Copyright 2020

A Norwegian SKJOLD class fast attack craft pictured during the 2000 Frozen Nozzle exercise. Norway is one of a number of small countries that needs to secure its sovereignty over far-flung Arctic territories.

time Exclusive Economic Zones (EEZs) – the United States and Canada disagree over a Slovenia-sized wedge of ocean north of the Alaskan-Canadian border, while Norway and Russia disagree over the extent of Norway's EEZ around Svalbard, an area about the size of Germany. Other maritime disputes are more abstruse. Both Canada and Russia claim full sovereignty over the Northwest Passage and Northern Sea Route, respectively, while many other nations maintain that their ships can freely transit those waters under the "right of innocent passage." For Russia, this is also an economic issue, since it charges tolls for ships passing through the Northern Sea Route. Separately, Canada, Denmark, and Russia have submitted competing claims to a United Nations committee regarding exclusive mining rights in parts of the central Arctic Ocean. However, these claims are being evaluated peacefully based on data regarding the seafloor, and are largely theoretical in any case, given the likely difficulty and cost of mining hundreds of miles from land in the forbidding central Arctic.

Resource-centred competition in the Arctic is not only about sovereignty, but also about economic and political influence. Tying back to the second driver, over the last decade, Chinese companies' interest in buying lands and mining rights in Greenland and Iceland have raised political alarms regarding those companies' links to the Chinese government. Another issue is the link between resource exploitation and Greenlandic independence. If Greenland prospers by selling its mineral or fish resources, that could reduce its economic dependence on Denmark, contributing to already strong pro-independence sentiment. An independent Greenland could reshape the military map of the Arctic, particularly if it decides not to permit NATO nations to base their forces there, greatly hindering the ability of NATO to dominate the approaches to North America and the North Atlantic.

Closing Remarks

The Arctic enjoyed a blessed interlude following the Cold War, when it was a relative backwater in terms of strategic competition. That interlude is now over. Due to a combination of Russian revitalisation and NATO reaction, Chinese involvement, changing accessibility, and copious demand for resources, the Arctic is an arena of substantial strategic competition. Not all of this competition is military in nature, with some of it focused on economic and political influence. Nonetheless, military competition is likely to grow given enduring Russian-NATO competition as a result of the Ukraine war. Russia may be inclined to be increasingly bellicose and militarily active in the Arctic, given that every other Arctic nation will soon be a member of NATO, and that NATO's Arctic frontiers with Russia will soon expand.

As long as Russia continues to threaten its neighbours at any latitude, the Arctic will be an arena of intense competition. This stems, in part, from the immutable fundamentals of Arctic geography. Despite its vastness and remoteness, it remains the shortest air route from Russia to North America. It is a good environment for submarines to hide in, and it is also ringed with maritime chokepoints that are natural focal points of naval competition, including submarine and anti-submarine warfare.

Regardless of the pace of climate change or technological advances, the Arctic will remain a harsh, challenging environment in which to operate. Even with considerable investment in building, repairs, and maintenance, infrastructure will continue to be scarcer than at lower latitudes. Some of these challenges can be alleviated through ever more extensive collaboration among NATO members. NATO militaries and their partners already conduct training and exercises together, share expertise on procedures and equipment, and benefit from joint infrastructure investments. Continuing to invest in such collaboration can make NATO ever more effective in the region, particularly when highly capable Sweden and Finland become full-fledged members. Above all, NATO nations must avoid the temptation to divert their attention away from the Arctic when crises develop elsewhere, as they inevitably will. Given the uniqueness of the region, sustaining a competitive position within it takes continual effort over extended periods. Continual investment in the specialised skills, equipment, and infrastructure that are needed to command the Arctic will be essential to avoid effectively ceding this important region to Russian domination. At the same time, there is a need to scrutinise China's activities in the Arctic, ensuring that its interrelated economic, political, and scientific activities do not create new threats. Such perpetual vigilance can help NATO nations to protect themselves and secure the northernmost reaches of the Earth.

Photo: Canadian Armed Forces

The Arctic region's changing accessibility, due to climate change and technological advances, is driving strategic competition. The acquisition of the Royal Canadian Navy's HARRY DE WOLF class Arctic & Offshore Patrol Ships (AOPSs) was largely driven by the greater maritime policing requirements these changes have driven.

Photo: Crown Copyright 2022

Royal Navy Surveillance and Reconnaissance Squadron (SRS) personnel deploying Inflatable Raiding Craft's (IRC) from a submarine at Lyngan Fjord in Northern Norway. Perpetual vigilance can help NATO nations to protect themselves and secure the northernmost reaches of the Earth.

Notes

1. For example, US law prescribes that the Arctic includes parts of western Alaska and the Bering Sea that lie south of the Arctic Circle. See the Arctic Research and Policy Act of 1984, Public Law 98-373.

Mine Countermeasure Vessel Programmes and Requirements in Europe

Guy Toremans

With their mine countermeasure vessels averaging about 30 years in age, most of the European navies are recapitalising their ageing MCM assets with a mix of "motherships" and unmanned "plug-and-play" systems to master a full "Detect-To-Engage" cycle.

The navies of Northern, Western and Southern Europe continue to invest the majority of the funding for new construction programmes, while the Eastern European navies, e.g. Bulgaria, Romania and Ukraine, are seeking to upgrade their existing hulls. As of September 2022, there are fourteen MCM projects in the pipeline for European navies, totaling 82 platforms. Five of these projects are in progress and nine are planned.


Photo: SAAB KOCKUMS

The Royal Swedish Navy is planning to replace its five KOSTER class vessels with new platforms based on Saab Kockums' MCMV 80 design.

Western European Navies

Both the **Belgian Navy** and **Royal Netherlands Navy's** (RNlN) bi-national Replacement Mine Countermeasures Capability Programme (rMCM CRP) is well underway. The keel of the first-of-class for the Belgian Navy – OOSTENDE – was laid on 30 November 2021 at the Kership[1] Shipyard in Concarneau and the keel for the first RNlN unit – VLISSINGEN – on 14 June 2022 at the group's facility in Lanester. The units will be handed over in 2024 and 2025 respectively. The ten follow-on vessels will be delivered at six-month intervals, alternating between the Belgian and Dutch navies, with all vessels scheduled to be in service by 2030. Both navies' TRIPARTITE minehunters will be outphased by 2028.

The **French Navy's** next-generation MCM capability - the Systems de Lutte Anti-Mines Future (SLAM-F) programme - is also progressing. The SLAM-F is eventually planned to comprise six motherships ("Bâtiments de Guerre Des Mines" – BGDM), eight Maritime Mine Counter Measures (MMCM) systems, five diver support vessels ("Bâtiments Base Plongeurs Démineurs" – BBPD) and a mine warfare data operating system ("Système d'Exploitation de la Guerre Des Mines" – SEGDM). The first of the MMCM system was delivered in November 2021, with another three anticipated by end-2023 and the remaining four by 2024; all five BBPD units are scheduled to be in service by 2025. The BDGM programme has not been launched yet but the Navy's requirements call for a platform suited to carry not only the MMCM drones, but also be able to operate the future larger AUVs and ROVs that will be needed to meet the French Navy's new "Seabed Control Operations' Strategy" intended to protect the country's interests to a depth of 6,000 m. A specific prerequisite is that the BGDMs must be capable of deploying the drones in, at least, a sea state 5 environment in order to check the approaches of the access channels to Ile Longue when the nuclear ballistic missile submarines deploy. As BGDMs will have a much larger geographical playing field (as far as the Indian Ocean, and even beyond), they must be able to provide supplies, technical support and command facilities in order to deploy an expeditionary mine warfare force far from their homeport. The first two BDGM are expected to join the fleet by 2026 and all six should be delivered by 2030. The Chantiers de l'Atlantique shipyard in Saint-Nazaire, France, is developing a 90-m "mothership" equipped with a floating cradle LARS able to operate USVs and AUVs up to 20 tonnes and a gantry system at the stern. The complete SLAMF project should be operational by 2030. Until then, the French Navy is to keep its ERIDAN class (TRIPARTITE) minehunters in service to avoid capacity shortages.

The **Royal Navy's** Mine Hunting Capability (MHC) programme is also making progress. The MHC programme includes the multi-mission Atlas Remote Combined Influence Minesweeping System (ARCIMS) USV. The first of three "operationally ready" MHC-Block 1 systems is scheduled for delivery in early 2023, the other two by end 2023. These autonomous systems are small enough to be easily transported by road, air, and sea, or fit into the mission bay of the RN's future Type 26 and Type 32 frigates or can operate from bases ashore or on "vessels of opportunity". In February 2022, AEUK was contracted to deliver a fourth ARCIMS USV, named RNMB HYDRA. The platform will be delivered by late 2022 and will undergo an operational evalua-

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1 Kership is a joint venture founded in 2013 by PIRIOU Shipyards in Concarneau and Naval Group in Lorient.

tion in early 2023 in the Gulf in support of Operation Kipion. The system will be embarked on board the forward-deployed BAY class dock landing ships that will act as mothership. AEUK is also due to supply three new SEACAT Medium Autonomous Underwater Vessels (MAUV) - capable to be deployed from the ARCIMS. Delivery of the MAUVs is anticipated in the spring of 2023. The new sweeps will be deployed using the RN's three existing ARCIMS USVs, namely, RNMB HUSSAR, RNMB HARRIER and RNMB HALCYON. The entry in service of the MHC USVs is aligned with the drawdown of the Navy's SANDOWN class minehunters between 2023 and 2025 and the HUNT class units to be retired by 2031.

The **German Navy's** requirement for maintaining mine countermeasures (MCM) and minelaying capabilities was documented in the "Capability Gap and Functional Requirement for a Combined MCM Capability Platform" concept. The new concept, for up to ten platforms, could begin as soon as 2023 in order to have the construction contract in place by 2027 and for the ships to be delivered from 2030 through 2034. To achieve a smooth transition, five of the remaining eight FRANKENTHAL class minehunters (DILLINGEN, HOMBURG, SULZACH-ROSENBERG, FULDA and WEILHEIM) are being upgraded with the latest version of the Atlas Elektronik Integrated Mine Countermeasures System (IMCMS).


Photo: BELGIAN NAVY

The keel for the first of the Royal Netherlands Navy VLISSINGEN was laid at the Kership facility in Lanester on 14 June 2022.

Northern European Navies

The **Danish Navy** is upgrading its MCM Denmark "toolbox". The two HOLM class MSDs will be equipped with the Portuguese Oceanscan Marine Systems and Technology's Lightweight Autonomous Underwater Vehicles (LAUV). The Navy took delivery of the first of six LAUVs in May 2022. The five other systems will be delivered by end-2023. The Minor Standard Vessels (MSF) are being fitted with the Kraken Robotics' SeaScout system, made up of a KATFISH 180 towed Synthetic Aperture Sonar vehicle and Autonomous Launch and Recovery System (ALARS)

The **Royal Norwegian Navy** is to renew its MCM force under the "Future Norwegian Maritime Mine Countermeasure Capability Project 6359". This project calls for the procurement of two motherships and three modular transportable MCM toolboxes that are also deployable from non-specialised vessels, offshore- and shore based installations, as well as transportable by road and air. Although no shipyard has been selected at time of writing, Umoe Mandal and Vard could be candidates. The RNoN plans to have the project fully operational in 2028. Until then the two remaining minehunters (MÅLØY and HINNØY) and two minesweepers (OTRA and RAUMLA) are to remain in service and receive minor upgrades.

In February 2022, the **Finnish Navy** launched a call for tender to replace the KIISKI and KUHA class inshore minesweepers under the designation Minesweeping Capability 2030 (Raivaamiskyky 2030 / RAKY2030). Requirements are for up to seven new platforms. With an approximate length of 24 m, these platforms should be able to embark autonomous and remotely controlled systems that are capable to sweep acoustic, magnetic and influence mines and feature sufficient deck space to deploy remotely controlled minesweeping equipment. Possible candidates to build these new vessels could be the Finnish Uudenkaupungin Työvene Shipyard, Sweden's Swede Ship Marine AB and Italy's Intermarine.

The **Royal Swedish Navy** will replace its five KOSTER class MCMVs with new platforms likely based on Saab Kockum's MCMV 80 design on a one-for-one basis. These 80-m-long platforms, displacing 1,250 tonnes, are suited to operate both in the minefield as a dedicated MCM platform, as well as outside the minefield acting as a mothership for drones. A construction contract could be in place as early as 2023, with the first unit to join the fleet by 2025.


Photo: Guy Toremans

KORMORAN, lead ship of the Polish Navy's new KORMORAN II class minehunters.

The Baltic Navies

In June 2022, the **Polish Navy** placed an order for a second batch of three KORMO-

Photo: Polish Navy

ALBATROS is the second of the Polish Navy's first batch of three KORMORAN II class minehunters.

RAN II minehunters, to supplement the initial batch of its three new KORMORAN II MCMVs, i.e. KORMORAN, which entered service in November 2021; ALBATROS delivered on 12 August 2022 and MEWA expected to be delivered in November 2022. The three additional minehunters are anticipated to enter service in the 2026–27 timeframe.

Although over the past decade, the **Estonian, Latvian** and **Lithuanian navies** acquired upgraded second-hand minehunters from the RNlN and RN, they are looking to further enhance their MCM capabilities. The **Estonian Navy** will replace its three ex-RN SANDOWN class minehunters, transferred between 2006 and 2009, under the Maritime Mine Countermeasures-New Generation (MMCM-NG) programme. A Request for Proposals (RfP) could be issued as early as in 2024 to have a construction contract in place by 2025 and have the three new units operational in the 2030. The **Latvian Navy** is upgrading three of its five IMANTA class (ex-Dutch ALKMAAR class) minehunters with an ECA Group's UMIS unmanned MCM suite - e.g. a C² and Mine Identification and Disposal systems (MIDS). Each of the minehunters' legacy MCM suite is replaced by an A-18M AUV fitted with the UMISAS synthetic aperture sonar, two SeaScan and ten K-Ster ROVs. ECA is also upgrading the ships' navigation systems with a W-ECDIS, an iXblue's PHINS C7 inertial navigation system, and a SIREHNA autopilot. The factory acceptance tests of the C² and MIDS have already been underway since August 2022.

In April 2020, the **Lithuanian Navy** signed an agreement for the transfer of the RN's decommissioned minehunter QUORN and subsequent upgrade to bring the minehunter up to an operational state similar to that of SKALVIS (ex COTTESMORE) and KURŠIS (ex DULVERTON) transferred in 2011. A contract for the ship's refurbishment was signed in July 2022.

Southern European Navies

The **Spanish Navy** will keep its six SEGURA class minehunters operational at least until 2030. The sea service plans to equip the METEORO class multirole offshore patrol vessel with Navantia's SIRAMICOR remote influence mine action tracking system. Ongoing defence cuts keep delaying the finalisation of the project though.

The **Italian Navy** awarded a contract to Intermarine for the development of the next-generation of MCM platforms ("Caccamine di Nuova Generazione"). The programme calls for twelve motherships in two versions: eight 60-m-long New Generation Coastal MCMV ("Cacciamine di Nuova Generazione Costiero" (CNG-C)), and four 80-m-long New Generation Offshore MCMV ("Caccamine di Nuova Generazione d'Altura" (CNG-A)). The CNG-C will have an MCM "toolbox" quite similar to the BE/NL rMCM CRP toolbox, while the 80 m CNG-A vessels feature a small flight deck for the operation of Unmanned Aerial Vehicles (UAV) and embark a more comprehensive MCM toolbox. It is anticipated that the construction of the first ship can start by 2028.

The **Hellenic Navy** is likely to enhance its MCM capability with up to six RNlN ALKMAAR class minehunters. The Greek Defence Procurement Agency signed a Letter of Intent (LoI) with the Dutch Defence Materiel Organisation (DMO) in November 2021 for the transfer of these minehunters. The delivery timeline is linked to the introduction of the Royal Netherlands Navy's new rMCM CRP platforms (VLISSINGEN class) and the subsequent decommissioning of the ALKMAAR class minehuners, though.

The **Turkish Navy's** plans to replace its five ENGIN class (ex-French CIRCÉ) units with a follow-on class to the six AYDIN class minehunters continue to be deferred due to the naval staff prioritising the procurement of larger platforms and submarines. The new MCMV project is now anticipated to start by 2025. Istanbul Naval Shipyard can be considered the leading contender for the programme as this shipyard has experience with the construction of five of the AYDIN class MCMVs in cooperation with the German Abeking & Rasmussen and Lürssen (today: NVL) shipyards.

The **Croatian Navy** stated its requirement for four new MCMVs. under Long-Term Development Plans (LTDP) 2015-2024. However, the lack of funding has pushed the project back to 2028 at the earliest. Should sufficient funding not be available, the sea service may look at the second-hand market to procure MCMVs. A navy

Photo: Polish Navy

MEWA, third of the Polish Navy's first batch of three KORMORAN II class minehunters.

source said that negotiations are underway with the German Navy for a transfer of two KULMBACH class units.

Eastern European Navies

Due to the use of naval mines in the war in Ukraine, mine clearance is to become a priority for the Black Sea countries near the conflict region. Mines have drifted ashore on the littorals of Bulgaria, Romania and Turkey, causing concerns over the safety of commercial shipping. It can be anticipated that the region will witness a surge in minesweeping operations Any demining operation in the Black Sea is likely to involve the MCM fleets of the following countries respectively.

The **Bulgarian Navy** acquired the two former RNlN ALKMAAR class minehunters MESTA (ex- MAASSLUIS) and STRUMA (ex-HELLEVOETSLUIS). These units supplement the BRIZ, TSIBAR (ex-Belgian MYOSOTIS) and six OLYA class inshore minesweepers. With the sea service planning to add a drone capability on its three TRIPARTITE minehunters, the procurement of new construction platforms will likely be delayed until 2030.

The **Romanian Navy** also needs MCMVs to replace its four MUSCA class minesweepers. Due to a limited budget, second-hand vessels, updated with modem minehunting systems may provide an interim solution until the necessary budget becomes available, likely with MCMVs that are to be phased out by the navies of Belgium and the Netherlands, or the Royal Navy.

The **Ukrainian Navy** has only one YEVGENYA class minehunter in its inventory, though its operational status is uncertain. The sea service is to receive the Royal Navy's two former SANDOWN class minehunters, ex-HMS RAMSEY and ex-HMS BLYTH. Both minehunters are undergoing an extensive overhaul at Babcock's Shipyard in Rosyth while the future Ukrainian crew is in training. Initially planned to arrive in Ukraine at the end of 2022, the exact time is still uncertain. As an interim solution, the naval staff is considering to equip the US-received Mark VI patrol boats with "clip-on" influence minesweeping systems to perform MCM roles. The UK is also giving six REMUS type ROVs and related training for Ukrainian personnel by the Royal Navy's Diving & Threat Exploitation Group.

Technology Advancements and Challenges

With sea mines becoming increasingly smarter - able to distinguish between targets, resist countermeasures and even relocate themselves – it is imperative that European navies strengthen their MCM capabilities to deal with the increasingly complex and ever-changing threats. Obviously, the market for modular unmanned autonomous systems is set to increase significantly in the coming years. In line with the European Union's PESCO project Maritime semi-AutonomouS Mine Counter Measures (MAS MCM) and funded by the European Defence Industrial Development Programme (EDIDP), Naval Group Belgium leads the Mine Risk Clearance for Europe (MIRICLE) project. A consortium, consisting of 19 partners from ten countries, is looking at a roadmap for the next generation "made in Europe" countermeasure solutions (for details see article headlined "EU Looks to MIRICLE..." elsewhere in this issue). Whereas navies tended to focus on mine hunting, they have also become cognisant that minesweeping capabilities have to remain available in the MCM toolboxes. A significant challenge is to develop more compact and lighter sweep sources, hence the European Defence Agency's Modular Lightweight Minesweeping (MLM) project sought to demonstrate modular lightweight sweep technology. Some of the potential solutions include the Finnish Patria's SONAC ACS acoustic influence sweep module and the Polish CTM's MLM-3100 magnetic influence sweep system and the Elementary Electromagnetic Generators surface module (EEG/S) influence sweep system. Technologies and techniques for underwater explosive ordnance disposal are also booming. Some developments include ECA's A-9M and the A-9E AUVs, L3 Harris Calzoni's HUNTERWATER, Atlas Elektronik's COBRA MDS and Saab's compact mine-killing SEA WASP ROV that can neutralise three mines in a single mission, which is quite unique.

Other areas becoming increasingly important are smart software packages to enable MCM mission planning and the management of multiple unmanned vehicles and artificial intelligence (AI). Software provider Seebyte developed the multi-domain control system SeeTrack V4 to manage multiple platforms and sensors at one time. Moreover, Thales developed a Mine Intelligence Mapping system (Mi-Map) and an AI-assisted solution for mine warfare analysis. For those navies intending to maintain and optimise their existing MCMVs, or consider the acquisition of pre-owned vessels, ECA Group offers a comprehensive drone solution, specifically designed to be fitted during modernisation programmes such as the aforementioned upgrade of the Latvian Navy's IMANTA class minehunters.

Although great progress has already been made to improve the USVs' autonomy, there are still several aspects to be looked at. These include communications robustness, bandwidth availability, sufficient power for propulsion and sustained use of the organic sensors, foul weather operation, network capacity, sufficient autonomous decision-making capabilities to return to base in the event that contact is lost and importantly, cyber vulnerabilities.

Photo: Danish Navy

The Danish HOLM class multi-role craft (MSD) will be equipped with the 2.3 m long LAUVs configured with a Klein high-resolution side-scan sonar, an iXblue navigation system, a Nortek doppler log and various communication systems for data exchange.

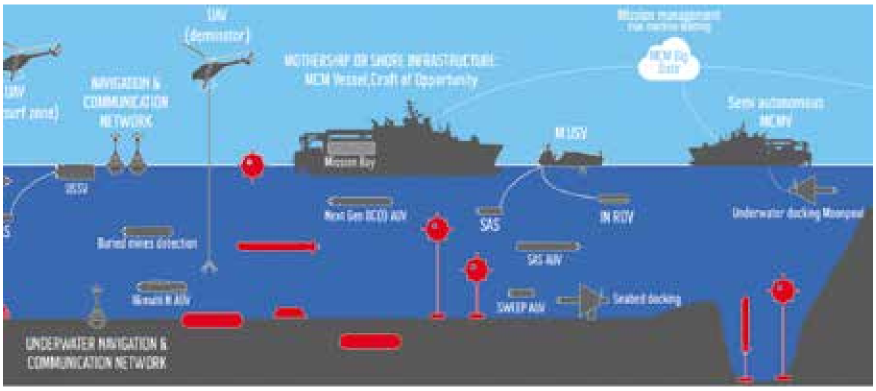
EU Looks to MIRICLE for MCM Future

Tim Guest

European navies are set to benefit from new levels of interoperability and capability in the field of mine countermeasures if the EC-sponsored project MIRICLE – "MIne RIsk Clearance for Europe" – has anything to do with it.

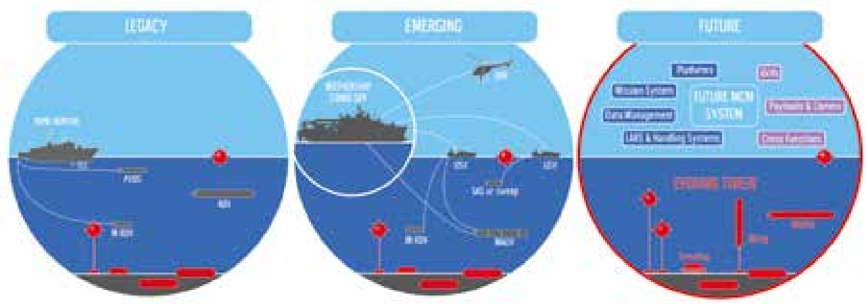
Being conducted in the shadows of an unexpected, major conflict in Europe, project MIRICLE is even more relevant now, as littoral and deeper regions of the Black Sea become cluttered with sea mines of varying kinds, including unmoored, drifting Soviet-era weapons. MIRICLE, which recognises the shifting trends away from traditional MCM using minehunters, to a stand-off MCM concept, aims to develop the main components of a new mine warfare solution and could not have come at a more urgent time. This article takes a look at project MIRICLE, its aims and objectives, together with a snapshot of the capabilities and expertise being drawn upon from among some of its industry participants in its quest to define and develop a technology and roadmap for next-generation, European maritime MCM capabilities.

Image: Naval Group



MIRICLE encompasses all aspects of autonomous and semi-autonomous systems, as well as subsea communications and navigation solutions for MCM evolution.

Image: Naval Group



Legacy, emerging and future MCM capabilities

Setting the Scene

Interoperability between European and NATO allied armed services is more crucial than ever in almost all aspects of tri-service operations as a result of Russia's unconscionable invasion of Ukraine. In the field of maritime MCM, project MIRICLE has interoperability between European navies in MCM as one of its key aims. And while cooperative MCM operations have been part of European/NATO maritime mix for many years – the Standing NATO Mine Countermeasures Group 1 (SNMCMG1), for example, already provides NATO allies with an immediate operational response capability and has done since the early 1970s, often working alongside various NATO and European MCM naval units on such tasks as de-mining operations in the Baltic Sea, where some 80,000 WW2 sea mines still imperil maritime traffic to this day – project MIRICLE underpins the need for even greater cooperation and interoperability in this area between all allied EU member navies. NATO, nevertheless, will be watching very closely – the project is actually being conducted in accordance with NATO recommendations.

Sponsored by the EC together with eight EU member states and with additional funding from the European Defence Industrial Development Programme (EDIDP), 19 industry partner companies have been selected to participate. These consortium companies are all now working to come up with technologies and solutions to strengthen interoperable and cooperative European naval MCM capabilities for use in the toughest environments and against all emerging threats, drawing on and developing their own relevant areas of expertise, which, in some cases, already includes MCM-related work and portfolios.

The EC has stated that it considers European navies to have developed unique mine action capabilities and a high level of operational excellence due to the massive use of sea mines in and around European waters during the 20th century; MIRICLE will, thus, reinforce those MCM capabilities to keep pace with an ever-evolving, complex and pervasive mine threat; the programme's two-year timeframe is seen as the time necessary for each player to develop the first technological bricks that will lead, ultimately, to a final MCM solution.

MIRICLE in Focus

Project lead, Naval Group Belgium, was selected by the EC in July 2021 and approved by member states. The company hosted its first meeting of the 19 industry participants at the beginning of December 2021, signalling the start of the 24-month project, which has been set in motion in recognition of the increasing threat of mines and improvised explosive devices present in all conflicts involving naval forces; the EC recognises that European nations need to strengthen the protection of their maritime domains to ensure their national assets and the freedom of all legitimate civil and naval navigation in their waters are safeguarded. This is where MCM has been undergoing a major operational transition in recent years, from traditional mine hunting to an MCM ecosystem involving unmanned and autonomous innovative solutions.

The 19 partners in the consortium are from 10 countries: Belgium, Estonia, France, Greece, Latvia, the Netherlands, Poland, Portugal, Romania, and Spain. Naval Group Belgium, as lead, is coordinating, managing and gathering together all work and results conducted by the consortium partners through its MCM Laboratory, which was launched last year at its premises in Brussels to support R&D collaborative projects; all Belgian members of the project are part of the new MCM Lab.

Aims and Objectives

MIRICLE is intended to facilitate significant improvements to the current methods of conducting MCM missions and will, more specifically, enable European navies to benefit from the very latest and most interoperable military MCM capabilities currently in use and/or in development and under evaluation, including within NATO. Indeed, MIRICLE will follow NATO recommendations and its innovations are intended to complement the main components of mine warfare, made up of Mine Counter Measure (MCM) vessel, the toolbox comprising unmanned vehicles and robots

Cooperative MCM operations have been part of European/NATO maritime mix for many years. NATO's SNMCMG1, for example, already provides NATO allies with an immediate operational response capability. MIRICLE aims at greater cooperation and interoperability among EU navies.

and the mission management system, the communication network and artificial Intelligence-powered decision making.

At the December meeting of industry participants, three of the key MIRICLE objectives set out and now in play, were:

- To provide a comprehensive and forward-looking definition and assessment of MCM technologies;
- To elaborate a technological development roadmap for next generation countermeasure solutions, one that corresponds with each member states' procurement plans and paves the way for future European Defence Fund (EDF) developments;
- To coordinate the development of new types of interoperable MCM assets, such as new vessel types, and interoperable MCM Toolbox assets.
- Achieving these objectives will involve the development of semi-autonomous MCM Vessel (MCMV) platforms, the improvement of interoperability and standardisation, the development of both a scalable intelligent multi-UxV mission management system and of an innovative UxV Launch and Recovery System (LARS). Studies, design, prototyping and test activities are all part of the programme and will help strengthen R&D cooperation and technical excellence in MCM among the partner European countries, in turn leading to European navies being able to reinforce their MCM capabilities with the very latest and optimally effective interoperable systems in order to keep pace with unfolding threats.

Image: ECA Group

ECA Group expertise that will contribute to the MIRICLE project include its UMIS solution that includes a wide range of unmanned vehicles such as USVs, UUVs (AUVs, ROVs, MIDS), towed systems (sonars, sweeps) and UAVs.

Operational Effectiveness

In terms of the operational effectiveness of any outcomes of the MIRICLE programme, objectives are for any solutions to be able to handle various specific mine scenarios, such as buried, concealed, drifting and deep mines, while also being able to operate efficiently and safely, decreasing the time and human effort required to conduct countermeasures operations and ideally removing the man from the minefield, completely -- all the while ensuring low risk to naval vessels. At the same time, solutions derived from the project must be highly versatile for use in different geographical locations and under all conditions, so they suit all operational, organisational and military approaches and strategies for the conduct of future MCM activities by all allied European nations.

And as well as delivering versatile, interoperable solutions, the project aims to deliver highly scalable systems that can be used to conduct multi-state, joint operations, and that have been created using a 'domestically European' supply of materials and information; the trend towards new European-led standards in this field are also expected to emerge through MIRICLE.

Consortium Players

Naval Group Belgium's MIRICLE project coordinator, Géraldine Dupin, said that the "unique" consortium was committed to help the European naval com-

Image: BNR

Belgium Naval & Robotics is the name of the Naval Group-ECA Group consortium responding to the Belgian-Dutch consultation for the replacement and initial support of their mine warfare capability, expertise which is expected to contribute to the MIRICLE project and, in turn, reap any rewards suited to the Belgium-Dutch requirement.

munity pursue the development of a "breakthrough mine action capability", drawing on the complementary technological skills and innovative approaches of its various industry partners. Together, the team intends to enhance MCM toolboxes to bring them to a higher degree of maturity by developing minefield instrumentation to optimise navigation and communication, which, in turn, will optimise mine detection, identification and, ultimately, neutralisation, even for mines deployed at very great depths.

The 19 MIRICLE partners comprise five major defence companies, four leading research establishments, two mid-size defence players and eight defence-industry SMEs. They are:

- Belgium - DotOcean NV, ECA Group, Naval Group Belgium (lead), Space Applications Services, Vlaams Instituut voor de Zee, (VLIZ);
- Estonia - Cafa Tech;
- France - ECA Robotics, Elwave SAS, Naval Group SA, Office National d'Etudes et de Recherches Aérospatiales, (ONERA), and Thales;
- Greece - Terra Spatium SA;
- Latvia - Belss Ltd;
- Netherlands – TNO, Forceapp BV;
- Poland - Ośrodek Badawczo-Rozwojowy Centrum Techniki Morskiej SA, (CTM);
- Portugal - Sistrade Software Consulting SA;
- Romania – Agenția de Cercetare pentru Tehnică şi Tehnologii Militare - Military Equipment and Technologies Research Agency, METRA.
- Spain - Sociedad Anónima de Electrónica, Submarina SME, (SAES);

Participating Expertise Brought to Bear

Let's now take a brief look at some examples of the expertise being brought to bear from a few consortium members within the MIRICLE project.

Lead Lays Keel

Underlining the expertise of the Belgian lead on the MIRICLE project, Naval Group Belgium, the company recently laid the keel for the second of the 12 MCM platforms for the Belgian-Dutch rMCM programme, VLISSINGEN, intended for the Royal Netherlands Navy, on 14 June. These specialised MCM platforms are the first to have the capability to embark and launch a combination of surface drones (themselves 12-metre, 20-tonne vessels), underwater drones

Photo: ECA Group

The INSPECTOR family of unmanned surface vehicles (USVs) developed by ECA Group constitute the company's latest solutions for future MCM applications.

and aerial drones. The MCM platforms will use a mainly autonomous system for detection, classification and neutralisation of mines; they can withstand underwater explosions and have very low acoustic, electrical and magnetic signatures, in line with mission requirements. Co-contractor, ECA Group, another MIRICLE participant, is in charge of the unmanned drones' system for the rMCM programme, with its UMIS unmanned system playing a key role, just as this expertise with be crucial to MIRICLE through ECA Robotics/ECA Group portfolios. UMIS is a modular solution that includes a wide range of unmanned vehicles such as USVs, UUVs (AUVs, ROVs, MIDS), towed systems (sonars, sweeps) and UAVs. It integrates the UMISOFT software suite allowing management of the entire unmanned mission from preparation, planning and supervision, to data acquisition, processing and analysis, all of which will be important to the success of MIRICLE, which the ECA Group as an opportunity for new operational capabilities to be designed, which will ultimately complete those that ECA GROUP and its partner Naval Group will deliver to the Belgian and Royal Netherlands navies.

CTM's Underwater Pedigree

MIRICLE's Polish industry participant, Centrum Techniki Morskiej, (CTM), develops underwater systems used to detect, classify and destroy sea mines. The centre develops solutions for non-contact minesweepers, magnetic-acoustic and remotely-fired charges designed to destroy anchored and sea-bed mines (set by remotely controlled underwater vehicles or a diver), as well as multi-channel fuses for non-contact mines. The centre specialises in the delivery of bespoke systems to detect and classify underwater diversionary threats, including how to counter and eliminate them. Its Underwater Monitoring System is based on two sonars: a hull mounted SHL-101/TM and an SHL-300 dedicated to submersible vehicles, which search for minefield objects, and its purpose is to provide the command system with data on any mine-like objects detected and located by the sonars. Displayed on its Underwater Weapons Multifunction Console, data from the sonars -- hydroacoustic images created from echo-location signals received by transducer assemblies – can be analysed to identify detected objects. In addition to sonars and minesweepers, another CTM accolade in this field is its TOCZEK explosive charges for sea mine countermeasures.

Photo: Saab

Thales' experience gained from the Maritime Mine Countermeasures (MMCM) Programme, involving development of a system comprising a tailored toolbox of autonomous seaborne drones, including Unmanned Surface Vehicles (USVs), is expected to be in support of the MIRICLE project.

MCM Lab, Brussels

Naval Group announced the creation of the MCM (Mine CounterMeasures) R&D centre of excellence within its subsidiary, Naval Group Belgium, in November last year. The centre will work jointly with Belgian partners in a collaborative laboratory called the MCM Lab, which will be instrumental to the MIRICLE consortium. The MCM Lab is a collaboration between Naval Group, Naval Group Belgium, ECA Robotics, ECA Robotics Belgium, ABC (Anglo Belgian Corporation), BATS (Belgian Advanced Technology Systems), DotOcean, Space Applications Services, University of Ghent, Université Libre de Bruxelles and Flanders Marine Institute (VLIZ). One of the main objectives of the MCM Lab is to reinforce the Belgian Defence Industry and Technology Base (DTIB) in strategic technologies, such as marine robotics, enhanced detection capabilities, and artificial intelligence applications for wider MCM capabilities. The lab brings together partners with complementary technological skills and innovative approaches to foster and stimulate close collaboration and its ambition is to become the European reference centre for mine warfare R&D and to play a key role in European initiatives in the MCM domain. It is actually one of the key components of the industrial cooperation associated with the Belgian-Dutch rMCMV programme, mentioned earlier. As for MIRICLE, five of the MCM Lab partners are participants in the project.

Photo: CTM

MIRICLE's Polish industry participant, Centrum Techniki Morskiej, (CTM), develops underwater systems used to detect, classify and destroy sea mines. (Shown here are the CTM premises in Gdynia, Poland.

European and US Heavyweight Torpedoes Continue to Evolve

Luca Peruzzi

The threat posed by the growing number of nuclear, conventional and AIP-propelled submarines, as well as new interest in midget platforms, has prompted European and US heavyweight torpedo (HWT) manufacturers to improve the performance of the latest generation of weapons through advanced batteries, sensors and life-cycle cost reduction technologies, as well as new operational software with advanced algorithms in response to state-of-the-art countermeasures.

The BLACK SHARK Advanced (BSA) is the latest generation of Leonardo's HWT. It is in service with the Chilean, Portuguese, Malaysian and an undisclosed Southeast Asian navy, identified by ESD as the Republic of Singapore, and more recently with the Indonesian Navy (on the three upgraded Type 209 JANG-BOGO class boats supplied by South Korea's DSME). The BSA is also being offered for the Indian Navy's procurement programme – albeit Leonardo does not confirm it – to equip the SCORPÈNE P75 and other in-service and future boats with new-generation HWTs. The BSA was developed under the Italian Ministry of Defence's Nuovo Siluro Pesante (NSP) programme to replace the A184 Mod 3 weapon.

Photo: Leonardo

The Leonardo BLACK SHARK Advanced is today in service with the second batch of Italian Navy's U212A platforms and is expected to be added to the first batch, while is also planned to equip the U212NFS (Near Future Submarine) version currently under construction.

Platforms for BLACK SHARK Advanced

The BSA is fully compatible with various classes of submarines equipped with different types of tubes and Combat Management Systems (CMS) (e.g. SCORPÈNE, U209, U212A, U214, U218, A17 ARCHER) and KILO type platforms. It is also currently being integrated into the platforms of an unnamed navy along with the new BLACK SCORPION 5 mini-torpedo, also produced by Leonardo, ESD has learned. As part of the BSA programme, Leonardo has developed a new Al-AgO primary battery (called Power) and a new Li-Po battery (called Energy) that will be delivered to the Italian Navy and all BLACK SHARK export customers. In December 2017, the Italian Ministry of Defense's Directorate of Naval Armament awarded Leonardo a contract for the delivery of a first lot of BSA, with additional (optional) lots, several training batteries and logistical support for an undisclosed number of munitions. Following the first batch, two additional batches were award-

Photo: Italian MoD/CIMA

Leonardo's BLACK SHARK is today operational with Chilean, Portuguese, Malaysian, an undisclosed South-East Asian country's navy, identified by ESD as the Republic of Singapore, and more recently with the Indonesian Navy.

ed to Leonardo for delivery in late 2022 and early 2023. The first batch of operational weapons was delivered in 2021 after an evaluation and firing campaign with an undisclosed number of firing trials (in addition to earlier industrial trials) with rechargeable and single-shot batteries. The firing campaign was conducted by two Italian Navy 212A submarines with standard configured weapons provided and certified by the Italian armed forces' Advanced Munitions Center (CIMA). The BSA is in service today on the second batch of U212A platforms equipped with the Kongsberg MSI-90U Mk2 CMS and is also scheduled to be deployed on the first batch, while it is also planned for the U212 Near Future Submarine (NFS) platforms under construction.
With a speed of more than 50 knots and a range of more than 50 km (depending on speed), the BSA differs from its predecessor mainly by a new Insensitive Munition (IM) with a warhead weighing about 250 kg provided by RWM and equipped with a LEFI (Low Energy Exploding Foil) fuze, a replaceable battery (either for deployment or exercises), new reinforced fibre optic cables, and customised tactical software with enhanced acoustic countermeasures (ACCM). BSA is available in a new single-shot battery configuration and a commercial lithium-ion polymer (LiPo) battery for crew training; both are already in service with the Italian Navy. The new single-shot aluminum silver oxide (Al-AgO) battery features an electrolyte circuit with a reduced acoustic signature that limits enemy submarine detection capabilities during the attack phase. The lithium-ion polymer (LiPo) battery produces 70% more energy and 100% more power than silver-zinc (Ag/Zn) batteries, has a longer life of 6-8 years (or more than 100 cycles) versus 12-18 months without maintenance discharge, and provides approximately five times the number of ignition/recharge cycles than Ag/Zn-based batteries.

Photo: Naval Group

Naval Group's new generation F21 HWT is equipping the new SUFFREN class SSNs and in the future SNLE 3G SSBNs, while replacing the F17 Mod 2 weapon in service with French Navy's LE TRIOMPHANT class SSBN and RUBIS class SSN submarines.

Photo: Naval Group

A new version of Naval Group's F21 is currently under development.

F21 Evolving

The F21 HWT was developed and procured under the ARTEMIS program, which was launched in January 2008 and awarded by the French Direction Générale de l'Armement (DGA) to the then DCNS - now Naval Group - in April of that year. The F21 HWT was conceived as a new generation HWT to replace the F17 Mod 2 weapon in service on the French Navy's LE TRIOMPHANT and RUBIS-class nuclear-powered submarines, as well as to equip the new SUFFREN-class SSNs and, in the future, the new SNLE 3G-class SSBNs. Following qualification trials in May 2018 with an off-the-shelf weapon from a RUBIS class submarine and the beginning of deliveries in September 2020, according to the French Parliament's budget documents, the F21, along with all other weapon systems, including the MBDA EXOCET SM39 anti-ship missile and the Naval Cruise Missile (NCM) or Missile de Croisière Naval (MdCN), successfully launched from the first SUFFREN class boat with various firing tests before the boat was officially delivered by Naval Group to the French DGA in November 2020 and entered active service in June 2022. The F21 has already enjoyed international success as it was procured by the Brazilian Navy for its new SCORPÈNE class conventional submarines.
With a length of 6 metres and a weight of less than 1.5 tons, the F21 provides a range of more than 50 km and top speed of more than 50 knots, with an endurance of about one hour without compromising safety and a mission depth of less than 10 to more than 500 metres. The F21 is powered by a new generation of silver oxide aluminum (AgO-Al) seawater batteries that use dissolved sodium dioxide powder as the electrolyte and incorporate a new electronic circuit system for the electrolyte. The battery delivers power regardless of depth. Compared to silver-zinc and other technologies, the energy density of AgO-Al is unmatched. "Along with Atlas Elektronik's silent electric propulsion system, which also delivers the fibre-optic cable routing, the F21 is equipped with an advanced mission system featuring a digital architecture with a multifunction acoustic head supplied by Thales and a high-performance computer that provides combined signal and data processing in real time," according to Naval Group documents, "allowing the F21 to

Photo: Atlas Elektronik

In March 2022, the Greek Directorate General for Defence Technology and Investment announced the award of a contract to Atlas Elektronik for the supply of the SeaHake Mod 4 HWTs.

maintain a clear picture even in the tightest coastal areas and against the most sophisticated torpedo defense systems."

The new torpedo features a 250-kg B2211D insensitive explosive warhead that meets insensitive munitions standards (STANAG 4439 and 4187) and also complies with additional French Navy requirements for integrating weapons aboard nuclear submarines.

The training version of the torpedo is equipped with a lithium-ion secondary battery supplied by Saft, which has limited energy compared to the primary battery but provides sufficient power for training in addition to the same top speed of the combat version and at least 50 recharge cycles over five years, thereby significantly reducing the life cycle cost of the F21.

Due to the difficulties encountered during the development programme, including the initial collaboration with Italy and the selection of a new propulsion system to keep pace with the commissioning of the new-generation boats, the French DGA decided to revise the programme. The weapons delivered are an initial capability version, but at the same time the DGA has been working on a new solution to meet all requirements, according according to a statement of the the head of the DGA in 2021. The latter is to have a new rear part (propulsion) supplied by France to meet national requirements by 2023-2024. No further details were provided, but according to the 2022 budget documents, the French DGA decided in April 2021 to initiate development of the "F21 Mk2 standard" with unspecified software and hardware improvements.

New Customers for SeaHake Mod 4

In March 2022, the Greek Directorate General for Defence Technology and Investments (GDAEE) awarded a contract to Atlas Elektronik for the delivery of the SeaHake Mod 4, which is based on the technology of the DM2A4 SEEHECHT HWT that was introduced by the German Navy in 2008. Since then, the weapon has been delivered to or is on order with at least ten international navies including Israel, Norway, Pakistan, Spain and Turkey. The SeaHake Mod4 is based on a modular bat-

Graphic: Atlas Elektronik

Historical survey of Atlas Elektronik's trorpedo development efforts

Photo: US Navy

US Navy is continuing working on new software and tech insertions (hardware) packages under the Mk 48 ADCAP (ADvanced CAPability) research, development test and evaluation (RDT&E) programme.

tery concept (with two, three or four silver-zinc (Ag/Zn) batteries) with inherently safe chemistry and very short activation time ("snap shot capable") and an electronically commutated permanent magnet motor, which in the more powerful four-battery configuration can achieve a speed of more than 50 knots and a maximum range of over 50 km. With a length of 6.9 meters including guidewire manifold in the most powerful four-battery configuration (approximately 6.22 meters as standard), the SeaHake Mod4 has been integrated into a number of submarine classes, including Types 209, 212A/214, S-80, AGOSTA 90B and DOLPHIN, capable of employing various weapon delivery techniques (swim out, push out, steam or ram). The SeaHake Mod4 features a hydroacoustically optimised homing head with an extended angle-of-view sonar array, fibre-optic wire guidance, tracking sensor and wideband digital signal processing, which Atlas says provides better tracking and manoeuvring capabilities, reduced inherent noise, and superior classification and discrimination of targets, jammers and decoys in active and passive modes. The weapon is available with a silver-zinc or lithium-ion practice battery. The latter is based on lithium iron phosphate chemistry and has been qualified by the German Navy and supplied to undisclosed export customers. This battery is intrinsically safe and can be recharged more than 200 times within a lifetime of at least 5 years. In November 2020, the German procurement agency BAAINBw awarded a contract to Atlas to phase out phase out the German Navy's obsolete torpedoes in service and introduce full digital data processing, which will also form the basis for performance improvements and compatibility with future submarine classes. The German company Atlas has also developed an extended range (ER) version that can operate at distances in excess of than 140 km beyond the length of the fibre optic cable via a communications section with GPS navigation antenna and satellite communications for coastal defence applications. In addition to commercialising SeaHake Mod 4, such as for Indian Atlas Elektronik, the company is also diversifying its HWT portfolio, offering potential customers the SeaHake Mod4 Open Architecture solution, technology transfer and joint development opportunities, in addition to upgrading older SUT and DM2A3 HWTs under the SeaDevil solution.

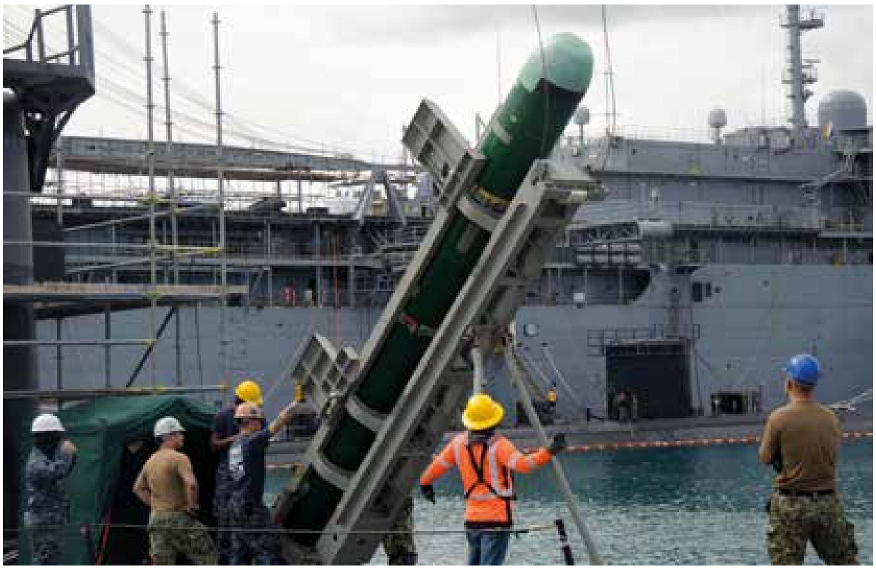
Continuing Upgrades to the US Mk 48

The US Navy continues to develop new software (APB, Advanced Processor Builds) and tech insertion (TI) packages (hardware) under the Mk 48 ADCAP (ADvanced CAPability) Research, Development, Test, and Evaluation (RDT&E) programme to keep the Mk 48 torpedoes modern and adaptable to new threats, such as shallow waters that are considered operational areas for adversary Third World diesel submarines.

In parallel, the US Navy is continuing its so-called "Mk-48 Restart Programme", launched in 2016, to maintain its HWT inventory, awarding contracts to Lockheed Martin and SIAC (Science Applications International Corporation) for the production of upgraded guidance and control units and caster/tail cone sections, respectively, as retrofit kits to be available beginning in FY 2022. These will be assembled by the US Navy Undersea Warfare Center maintenance facilities with warhead electronic units and fuel tanks supplied by the same service. These contracts also include export options for countries that have procured the MK-48 torpedo or want to extend the life of their Mk 48 stocks, such as Canada and the Netherlands, as well as Taiwan as a new customer. Together with the US, Australia funded the development, testing and production of the in-service version of the Mk 48 Mod 7 Common Broadband Advanced Sonar System (CBASS) and plans to further upgrade the weapon with new APB/IT.

The US Navy's Mk 48 Mod 8 (APB 6/TI-1) programme provides for a significant upgrade to the Mk 48 Mod 7. The torpedo is

Photo: US Navy



In 2016, the US Navy launched a Mk48 restart production programme which sees upgraded guidance & control, afterbody/tailcone as well as warheads electronic sections and fuel tanks being acquired as upgrading kits.

to be improved with APB 6 operating software and TI-1 hardware upgrade. The latter includes a new command and control unit with a new sonar system (higher density array, transmitter and receiver), command and control box, tuning box and Ethernet device switch. A new electronic warhead system will also be installed to support improved ignition and an improved post-launch communications system (IPCLS), the latter replacing copper cable with fibre optics. These improvements, according to the US Navy, are needed to increase capabilities in advanced countermeasures, shallow water, low Doppler frequency targets and surface engagements. The TI-1 package will also include features from three undisclosed Office of Naval Research (ONR) FNC programmes. The Mod 8 G&C sections will enable full fleet deployment of the APB-6 mission software package, development of which began in FY 2018 and will be completed in the second quarter of 2025. The TI-1 hardware package runs from late FY 2019 through Q2 2026, with development testing for both packages spanning 12 months from Q3 2025 through Q3 2026, followed by operational testing in Q3 2026. The Mk 48 Mod 9 (APB 7/TI-2) will offer significant improvements over the Mk 48 Mod 7 and Mod 8 versions, including propulsion improvements that provide longer range and enhanced reconnaissance capabilities against surface and subsurface targets. According to the US Navy, the Mod 8 and Mod 9 versions are intended for different operational purposes. Improvements include software upgrades for APB 7 and hardware upgrades for TI-2 that provide advanced acquisition, processing and propulsion technologies developed under OSD's SCO and ONR's FNC research and development programs. Prototype testing and demonstrations began in early FY 2021 and will continue through the end of FY 2025. Software and hardware package development is scheduled to begin in early FY 2023 and continue through the end of FY 2027.

SPEARFISH Mod 1 is Operational

Commissioned in 1994, the Royal Navy's arsenal of SPEARFISH HWTs is now the subject of a modernisation programme that manufacturer BAE Systems was tasked with in 2014 to keep the system in service beyond 2050. As part of the programme to upgrade the SPEARFISH to Version Mod 1, which aims to overcome system obsolescence, improve capabilities and reduce life-cycle costs, BAE Systems and the UK MoD have successfully completed the develop-

Photo: UK MoD Crown Copyright

BAE Systems and the UK MoD have successfully achieved equipment delivery of the SPEARFISH upgraded weapon (Mod 1 version) in March 2021 with its initial operational capability (IOC) declaration.

Photo: UK MoD Crown Copyright

The upgrading activities of in-service SPEARFISH torpedoes to the Mod 1 version by BAE Systems is expected to be completed by 2024.

Photo: Roketsan

In March 2022, the Turkish MoD announced the successful life firing of the new and indigenously developed and Roketsan-produced AKYA HWT from an upgraded PREVEZE class (Type 209/1400) submarine.

Photo: Roketsan

The new AKYA HWT is a dual purpose HWT that is effective against both submarines and surface vessels with a 50+ km range and 45+ knots speed.

ment phases that lead to delivery of the upgraded weapon (Version Mod 1) in March 2021 and declaration of initial operational capability. This included the delivery of the first modification kits for the weapon and logistical support. In accordance with the UK MoD's Defence Equipment Plan 2021, the modernisation programme successfully completed sea trials at the Atlantic Undersea Test and Evaluation Centre in the Bahamas and achieved the spring 2021 delivery date, enabling the weapon to be delivered by summer 2022.

BAE System's modernisation of the in-service weapons is scheduled to be completed by 2024. The SPEARFISH Mod 1 version will reuse the torpedo hulls and Sundstrand 21TP04 thermal propulsion system, but will introduce a number of improvements, including a digital weapon architecture (both hardware and software), a new fibre optic cable routing system to replace the current copper/cadmium cables, and a new warhead to meet insensitive munitions (IM) requirements. The Mod 1 weapon will also be converted to a single-propellant propulsion system, which offers cost and safety advantages over the current dual-propellant (HAP-Otto) system. Major subcontractors include MBDA TDW (insensitive warhead), Atlas Elektronik (fibre optics and signal processing) and Altran Technologies (safety electronics).

A New Weapon System from Turkey

In March 2022, the Turkish Ministry of Defense announced the successful tests of the Roketsan-manufactured and domestically developed AKYA HWT from an upgraded PREVEZE-class submarine (Type 209/1400). The tests were conducted against a real target for the first time after the Type 209/1400 submarine GÜR fired the first guided shot in January 2021 at the test range in the Sea of Marmara. The AKYA national torpedo development programme was launched in 2009 under the auspices of the Turkish Procurement Agency (SSB) to develop a fully indigenous product. All components are to be supplied by domestic companies, so developing the know-how took some time. Roketsan was the prime contractor during the development phase, along with the Turkish Navy Research Center (ArMerKom) and a national industrial team that included Meteksan Defence, which was responsible for the sonar transducer arrays (sonar wet side), and KBS for the wake vortex sensors, the underwater detection and positioning system for the torpedo test range, the acoustic signal generators and the underwater acoustic models. Roketsan is responsible for the warhead and guidance system, while Tübitak was involved in integrating the new torpedo with the first domestically manufactured MÜREN command management system. Following the successful completion of Phase 1, SSB contracted Roketsan in July to industrialise the AKYA prototype (Phase 2) to bring it to production readiness. This phase led to recent firing exercises and serial production, with the system expected to be available this year. According to the few details provided by Roketsan, the new AKYA system is intended to replace older in-service weapons such as the Mk14, Mk23, Mk 37 Mod 2 and 3, SST-4 Mod and Mk24 Mod2 TIGERFISH. It is a dual-purpose HWT effective against both submarines and surface ships with a range of over 50 km and a speed of over 45 knots. The AKYA has a brushless DC motor with counter-rotating propellers and is powered by a high-energy chemical battery. It is equipped with a two-way fibre-optic guidance link with internal navigation and a guidance system based on a hydroacoustically optimised homing head with active/passive sonar head and acoustic countermeasures, as well as a vortical sensor (capability for homing in on surface targets) and an insensitive warhead with "underwater shock effect" (capability) with proximity sensor/impact fuse and explosion.

Photo: Saab

The in-service Torpedo 62 (TP 62) HWT developed by Saab Dynamics for the Swedish Defence Materiel Administration subject to a life extension programme which was launched in July 2020.

The TP 62 Life Extension Programme

The Saab-developed Torpedo System 62 (TP 62) HWT, in service with the Swedish Navy's submarine fleet since 2001, is the focus of a life extension programme launched in July 2020. The initial four-year contract includes identification of improvement options. In December 2021, Saab was awarded a second contract for the next phase of the life extension programme, focussing on feasibility studies and prototype development, including subsystem demonstrators, to reduce risks and costs. The technologies and software packages come from the new Torpedo System 47 lightweight torpedo programme, which is also expected to be part of the future underwater weapons inventory of the Swedish submarine fleet. Work will run until the end of 2023, with production and development taking place in Linköping and Motala. According to the Swedish procurement agency FMV. The Torpedo 62 is equipped with an advanced propulsion system that enables high speed and long endurance, as well as an advanced homing system designed for the Swedish Navy's area of operations. ■

The Quest for Naval Firepower

Doug Richardson

For much of the first half of the 20th century, the most powerful form of naval firepower was that provided by the battleship, a veritable floating castle of steel armed with guns of more than 12 inch (300mm) calibre able to attack targets as distant as the horizon.

Yet despite the destructive potential of those heavy guns, naval gunnery of that era was a hit and miss process – with more misses than hits. During one naval engagement fought more than 80 years ago, a battlecruiser armed with 28cm guns and what was probably a state-of-the-art fire-control system expended about 200 rounds but achieved only around 10 hits on its opponents.

Given their growing uselessness in modern naval warfare, most battleships and battlecruisers were retired by the end of the 1950s, to be followed in the 1960s and early 1970s by most of the 6 inch (155mm) and 8 inch (200mm) gun-armed cruisers. The age of the naval big gun and multi-turret broadside was over; their role during what were essentially twilight years having been confined to shore bombardment. Today's warships tend to have one or more single or twin-barrel guns, with calibres typically ranging from 75mm to around 130mm.

Photo: UK MoD

The UK Royal Navy Type 45 destroyer DEFENDER fires its 4.5 inch Mk 8 Mod 1 gun.

Searching for a Standard

By the late 1930s the US Navy had standardised on 5 inch (127mm) calibre for its medium guns. Current weapons of this type fire a shell in the 25 kg class to ranges of 25 km or more. First adopted in the 1950s, the 5 inch/54 calibre Mk 42 gun was showing its age by the 1960s, so development of a replacement was begun. Developed by United Defense (now part of BAE Systems Land & Armaments) and designated the Mk 45, this was intended to offer significant improvements in reliability and maintainability. Initial versions were designated as the Mod 0 and entered service in 1971. The Mod 1 used on warships such as SPRUANCE class destroyers teamed a 54-calibre barrel with a new gun mounting.

The definitive Mod 4 version combines a 62-calibre barrel with a modified turret the flat-panel configuration of which is intended is intended to reduce its radar signature. It also features structural improvements needed to cope with the higher energies involved when firing advanced rounds, while as well as improvements to the ammunition magazine to help ammunition handling personnel with the tasks of handling and loading the gun.

Land-based testing of the Mod 4 gun began in August 1998, and in the following year an early example was installed in the ARLEIGH BURKE class AEGIS destroyer WINSTON CHURCHILL (DDG-81). This cleared the way for the Mod 4 to be installed on further ARLEIGH BURKE class AEGIS destroyers (DDGs 81-108) and retrofitted to some TICONDEROGA-glass AEGIS cruisers as part of the USN's Cruiser Conversion Program.

Developed by UK's Royal Armament Research and Development Establishment, and built by what was then the Armament Division of Vickers, the 4.5 inch Mk 8 entered service in 1973 on Royal Navy destroyer BRISTOL. It was based on the L13 105 mm weapon fitted to what was then the British Army's ABBOT self-propelled gun, and featured a gunhouse the outer shell of which was made of glass-reinforced plastic (GRP).

Given the threat posed by antiship missiles, rapid startup was seen as being more important than rate of fire, so the Mod 0 version was designed to fire its first round in less than ten seconds after being activated. Rate of fire is about 25 rounds per minute. During the Falklands War in 1982, reliability problems were reported, with some frigates having to cease fire on several occasions due to faults.

The follow-on Mk 8 Mod 1 version uses an electric loading system in place of the hydraulic loading mechanism of the Mod 0, and a reshaped gunhouse intended to have a lower radar cross section. The Mod 1 was adopted for the Type 45 destroyers, and retrofitted to Type 22 Batch 3 and Type 23 frigates, and two Type 42 Batch 3 destroyers.

When faced with the need to replace existing naval guns of various calibre, France

Author

Following an earlier career in engineering, **Doug Richardson** is a defence journalist specialising in topics such as aircraft, missiles, and military electronics.

opted to standardise on 100mm. The resulting MODÈLE 53 entered service in 1961. It required the first shell to be loaded manually, but the recoil from this first shot allowed the next round to be loaded automatically, making possible a rate of fire of up to 60 rounds per minute. An improved MODÈLE 64 increased the rate of fire to 78 round/min.

From the MODÈLE 68 onwards, the first round can be loaded automatically, but the rate of fire was reduced to 60 rounds per minute until the development of the CAD-AM (Cadence Améliorée) version allowed 78 rounds/min. France's LAFAYETTE class frigates are armed with the GIAT MODÈLE 100 TR, which has a lower radar signature. The COMPACT version is a lighter-weight variant that has been exported to China, Malaysia, Portugal and Saudi Arabia, and is made in China as the Type 210, a variant designed to be compatible with Chinese and Soviet-era shipboard electronics. It also has a modified magazine that is compatible with laser- and infrared-guided projectiles. China's follow-on PJ-87 100mm gun is reported to have reliability problems.

Several attempts have been made to develop naval guns of around 200 mm calibre, but none have seen operational service. In the early 1970s the USN's Naval Surface Warfare Center Dahlgren Division developed the Major Caliber Lightweight Gun (MCLWG), a single-barrel 8 inch (203 mm) weapon based on an earlier gun that had been used in triple turrets on the late 1940s DES MOINES class cruisers. A prototype was installed aboard the HULL (DD-945) in 1975, but the weapon's limited accuracy resulted in the programme being cancelled in 1978.

Photo: USN

Conducted at the Dugway Proving Ground, Utah, this test firing of the US Navy's 155 mm/62 Mark 51 ADVANCED GUN SYSTEM (AGS) was intended to demonstrate a new coating devised to extend the weapon's barrel life.

In 2004 BAE Systems proposed a 155mm calibre gun as a potential weapon for was then the planned Type 45 destroyers for the RN. Known as the 155 mm TMF (Third Generation Maritime Fire Support) this combined the 155 mm/39 gun barrel used on the British Army's AS90 BRAVEHEART self-propelled howitzer with the existing gun house of the 4.5" (114 mm) Mk 8 Mod 1. A potential Fourth Generation Maritime Fire Support weapon (FMF) based on a 155 mm/52 barrel would have required a strengthened gunhouse.

Having a common gun calibre for army and navy use would have simplified ammunition logistics, and raised the possibility that the two services could jointly develop extended range and precision-guided rounds, but the naval weapon fell victim to defence budget cuts in 2010.

Developed by BAE Systems Armaments Systems, the 155 mm/62 Mk 51 ADVANCED GUN SYSTEM (AGS) was created specifically for the USN's ZUMWALT class destroyers. A class of 32 ships had been planned, and was intended to give the USN the ability to provide long range naval gunfire support against shore-based targets. Rising costs resulted in the new class being scaled back to 24 ships, then finally to only three.

The AGS was intended to use the custom-designed Lockheed Martin Missiles and Fire Control Long Range Land Attack Projectile (LRLAP) precision-guided 155mm round. When procurement of these was

Photo: US DoD

The Venzuelan frigate MARISCAL SUCRE is armed with the Otobreda 127mm/54 COMPACT gun.

Photo: US Navy

This BAE Systems 57 mm Naval Automatic Gun L/70 is installed on the US Navy's littoral combat ship FREEDOM (LCS-1). Originally developed by Bofors, it has the US designation Mk 110.

scaled back to match the needs of only three ZUMWALT class destroyers, the unit cost of a LRLAP round rose from the $35,000 anticipated in 2004 to an eventual $800,000-$1,000,000, around that of a TOMAHAWK cruise missile. Such costs made the programme unviable, so the planned procurement of only about 2,000 rounds was cancelled in 2016. The USN now plans to remove the AGS guns from all three ZUMWALTs, and use the space these had occupied to house vertical launch tubes for the Conventional Prompt Strike (CPS) hypersonic missile.

Smaller Projectiles

While many navies favour guns of around 127-130mm calibre, some prefer weapons that fire smaller projectiles. More than 60 navies have adopted what started life as the OTO Melara 76mm naval gun with shells weighing around 6kg. When first fielded, the original COMPATTO version of the Italian gun had a rate of fire of 85 rounds per minute, but this was increased to 120 rounds per minute in the SUPER RAPIDO version that has been available since 1988. As its designation SOVRAPONTE ("over deck") indicates, this follow-on lightweight version requires no penetration of the deck, simplifying the task of mounting it on small warships. In 2006 Iran began production of its FAJR-27 copy of the Italian gun.

Thirteen navies have adopted an even-smaller calibre weapon – the Bofors 57 mm L/70 Naval Automatic Gun. Developed by AB Bofors (now part of BAE Systems AB), this fires a shell weighing about 2.4kg, and has a rate of fire of 200 or more rounds per minute. The original Mk 1 variant introduced in 1970 was adopted to arm small warships down to the size of fast attack craft, while the Mk 2 variant fielded a decade later combined a significant reduction in weight and new servo stabilisers. Development of the Mk 3 was largely spurred by the need to handle programmable ammunition, and this variant entered service in 1995.

Railguns

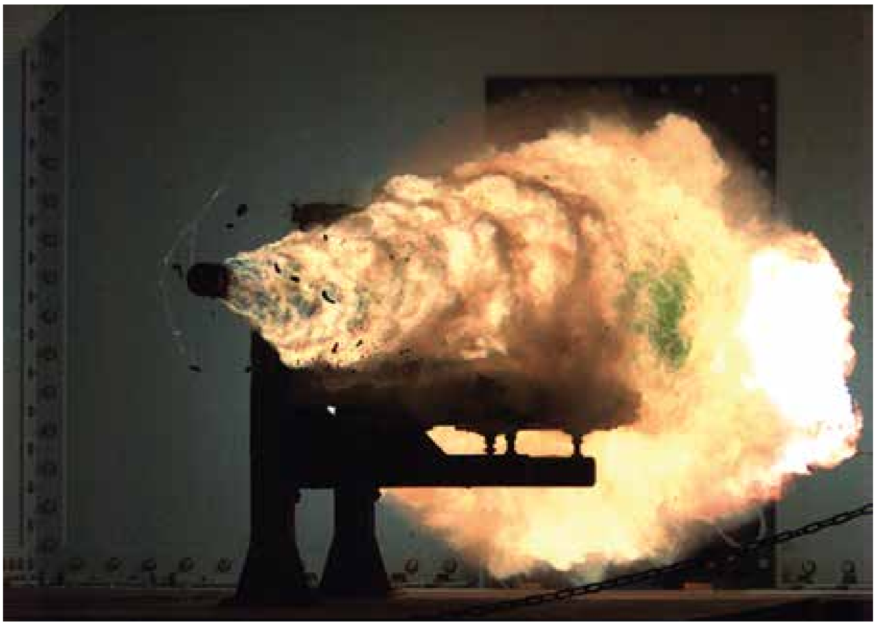
Current naval guns use explosives to launch projectiles at velocities of up to around 1.5 km/sec, but research is under way on railguns that would use electromagnetic force to launch projectiles at 2.5 - 6 km/sec. At these speeds, the projectile would not require an explosive payload, so could take the form of a solid object, the high speerd, mass and kinetic energy of which would be sufficient to inflict significant damage to the target.

A railgun would use a pair of parallel conductors (known as rails), a conductive armature, and a projectile positioned between these. A powerful electric current would flow down one rail, through the armature, then back along the other rail. The resulting electromagnetic force accelerates the armature and projectile along the rails. The large levels of current needed to drive the armature, and the inevitable friction between this and the rails will create high levels of heat that could potentially damage the rails, while the magnetic field that drives the armature and projectile also generates a sideways force on the rails. So, it is hardly surprising that early experiments suggested that major advances in materials technology would be needed in order to create a practical weapon.

Railgun technology is being developed by countries such as the USA, UK, France, Germany, Russia, and China, but does not seem to be maturing as rapidly as expected. If operational weapons can be developed for shipboard use, these will make severe demands on a warship's electrical power system by requiring high amounts of energy over very short periods of time, an intermittent load that could prove hard to satisfy in an era when other shipboard sensors, electronic systems, and weapons are likely to have an ever-growing appetite for electrical power.

China has made an experimental installation of a railgun on the 4,800-ton Type 072III class landing ship HAIYANG SHAN,

Photo: US Navy



A high-speed video camera captured this image of a test firing of an electromagnetic railgun at the US Naval Surface Warfare Center, Dahlgren, Virginia, in January 2008. The 3.2 kg projectile achieved a muzzle velocity of 2,520 m/sec.

and is reported to have begun test firings in 2019. In February 2015, the USN announced that it was considering the possibility of retrofitting an electromagnetic railgun on LYNDON B. JOHNSON, the third ZUMWALT class destroyer. This now-abandoned plan would have involved replacing one of the vessel's two AGS, and would have exploited the high level of electricity-generation capability of the ZUMWALTs.

Anti-Ship Missiles

The maximum range of naval guns such as the USN's Mk 45 is less than 40 km, and these typically fire projectiles in the 35 kg class, but many types of anti-ship missile can carry a high-explosive warhead weighing more than 100 kg over ranges of more than 100 km. While the gun still can play a major role in fire-support, its viability as an anti-ship weapon is now minimal.

By the late 2010s, the RN's HARPOON Block 1C anti-ship missiles were approaching the end of their service life, so would need to be phased out long before a long-term replacement would become available. In 2019 the UK MoD gave details of its plan to procure and deploy an Interim Surface-to-Surface Guided Weapon (I-SSGW) that could be deployed on a small number of RN warships for a period of about 10 years. Potential candidates were reported to be the SEA SERPENT derivative of the IAI GABRIEL V, Lockheed Martin's surface-launch AGM-158C LRASM (Long-Range Anti-Surface Cruise Missile), the MBDA EXOCET MM40 Block IIIc, the Raytheon/Kongsberg NAVAL STRIKE MISSILE (NSM), and Saab's RBS-15 Mk IV.

Photo: US Navy

HARPOON entered service in 1977 and is now used by more than 20 navies. This firing was conducted from the TICONDEROGA-class guided missile cruiser SHILOH (CG 67).

Photo: Saab

This artwork shows a salvo of two Swedish RBS 15 Mk IV GUNGNIR missiles, a weapon designed to attack naval and land targets.

LRSAM is based on the air-launched AGM-158B JASSM-ER (Joint Air-To-Surface Standoff Missile-Extended Range) and was designed to offer more sophisticated autonomous targeting capabilities than those available from the USN's current HARPOON anti-ship missile. Initial guidance is based on a multi-mode passive RF sensor, jam-resistant GPS/INS, and a new weapon data-link. Terminal guidance is provided by an imaging infrared seeker with automatic scene/target matching recognition.

Although the UK was offered LRSAM rather than HARPOON as a I-SSGW candidate, the older missile is still an effective system. The USN is updating its existing stock of HARPOON IC missiles to the HARPOON Block II+ standard, which incorporates an improved GPS guidance system teamed with a net-enabled datalink. These changes allow the missile to receive in-flight targeting updates. By fitting the missile with a more fuel-efficient engine and a lighter warhead weighing 140 kg, Boeing has created a Block II+ ER version with a range of 310 km, more than double the 130 km of the older variants.

Originally developed by Nord Aviation (later absorbed into Aerospatiale) and now an MBDA product, EXOCET missiles are currently in service with around 30 users. Most are powered by a solid-propellant rocket motor, but the Block 3 version uses a small turbojet engine that gives the weapon a maximum range of more than 180km. It also features a GPS subsystem that allows the missile to fly to predefined waypoints, and provides a limited ability to attack land targets.

The US has traditionally been reluctant to adopt non-US weapons, but in 2018 the USN adopted the Kongsberg NSM to meet its Over-The-Horizon Weapon System (OTH-WS) requirement. Boeing and Lockheed Martin had proposed HARPOON and LRSAM respectively, but in May 2017 both US companies opted to withdraw from the competition, leaving NSM as the only candidate. Each shipboard installation will consist of missiles, launchers, and an operator interface console.

Israel Aerospace Industries' GABRIEL anti-ship missile has evolved through several iterations since entering service in 1970. The latest variant is the GABRIEL V Advanced Naval Attack Missile used by the Israeli and Finnish navies. Designed to penetrate a target's soft- and hard-kill defences, it uses an advanced active radar seeker designed to cope with chaff, advanced decoys and active ECM.

At least two GABRIEL V sub-variants are known to exist. In 2020 IAI teamed with Singapore's ST Engineering to create Proteus Advanced Systems, a joint venture that is developing BLUE SPEAR, a version that combines maritime and deep land attack capabilities and has a reported range of at least 200km. Guidance is via a high-accuracy inertial system and an active-radar seeker. In October 2021, it was announced that the Estonian Defence Forces purchased a truck-mounted BLUE SPEAR system with a maximum range of 290 km. A later report that Estonia planned to transfer a single BLUE SPEAR system to Ukraine was denied by the Estonian Minister of Defence.

In 2021, IAI and Thales revealed SEA SERPENT, the version intended to meet the RN's short-lived I-SSGW requirement. The companies were reluctant to provide details of the new configuration, but stated that it would use "an innovative RF seeker head and a sophisticated data analysis and weapon control system" intended to cope with heavy levels of enemy countermeasures and radar clutter. It would also be able to accept mid-course updates and retargeting instructions. Maximum range in a low-profile flight mode would be more than 290km.

Saab's RBS 15 is another missile that had evolved over the decades since the original Mk I version entered service in 1984. Development of the RBS 15 Mk III began in the mid-1990s as a joint project in conjunction with Diehl Defence, and the resulting system is carried by the German Navy's BRAUNSCHWEIG class corvettes.

Co-operation between the two companies continued with the RBS 15 Mk IV GUNGNIR. Ordered by Sweden in 2017 with first deliveries scheduled for the mid-2020s, this has a longer range (more than 300km), and can be used against sea or land targets. Mid-course guidance is based on an INS coupled with jam-resistant GPS, while a J-band active-radar seeker is used for terminal guidance.

Selection of a winning design to meet the I-SSGW requirement had been expected by mid-2021, with deliveries expected in 2023-2024, but in February 2022 the programme was cancelled, leaving the UK with yet another 'capability holiday'.

France and the UK have teamed to study a Future Cruise/Anti-Ship Weapon (FC/ASW) – known in French as the FUTUr Missile Anti-Navire/Futur Missile De Croisière (FMAN/FMC) This is intended to replace the STORM SHADOW/SCALP cruise missiles, and EXOCET anti-ship missiles.

A joint study phase was initiated by both nations in 2011, followed in 2013 by the start of a joint concept phase by MBDA. This ended in 2021 having resulted in two possible solutions – a subsonic low-observable missile and a highly-manoeuvrable missile able to fly at high supersonic speeds. A bilateral agreement and contracts for continued preparatory work were agreed in February 2022, but any resulting missile is unlikely to see service until close the end of decade, or even the early 2030s. ■

Photo: US Navy

Launched from the US Navy Littoral Combat Ship CORONADO (LCS-4), this Kongsberg Naval Strike Missile (NSM) scored a direct hit on a mobile ship target.

Directed Energy Weapons at Sea

Suman Sharma

As warfare becomes state-of-the-art and weapons ever more lethal, directed energy weapons are proving to be revolutionary in arms technology.

In late 2016, American diplomats in Cuba complained of unexplained illnesses, with unusual symptoms and sensations, loss of memory, hearing and vision, plus problems in maintaining balance, headaches, and nausea. This phenomenon of inexplicable illnesses was later referred to as the "Havana Syndrome". In what was first considered to be a targeted attack, these occurrences were studied and found to have been caused by directed pulsed electromagnetic energy through focused radio waves.

As warfare becomes state-of-the-art and weapons ever more lethal, Directed Energy Weapons (DEWs) are proving to be revolutionary in terms of their sheer precision, range and lethality. Crime writer Patricia Cornwell once said, "If you can create a weapon that causes enough fear that fear itself can cause damage, that's as paralysing and destructive as any physical device like a bomb or a laser gun."

DEWs make use of extensive concentrated energy to neutralise targets as opposed to conventional weapons using a solid projectile. DEWs include particle beams, sound beams, beams of atomic and subatomic particles, lasers, microwaves, and radio waves, all of which are ranged and aimed at missiles, vehicles, personnel and optical devices. Considered an engineering marvel, these weapons appear to be straight out of a sci-fi movie with roots traced back to 212 B.C. when Greek mathematician Archimedes first invented and used a giant mirror in battle, designed to set invading Roman warships on fire by focussing the mirror in the sun's direction. There are reports about similar weapons also being used in WWII; though non-lethal, they generated a high density of acoustics, thereby unsettling the enemy through inducing nausea and vertigo.

More recently, it was former US President Ronald Reagan who proposed the Strategic Defence Initiative (SDI) in the 1980s, famously dubbed "Star Wars", to explore the possibilities of developing DEWs. While the project never took off, it was based on focused laser and X-ray energy aimed at intercepting intercontinental ballistic missiles.

Graphics: Lockheed Martin

Lockheed Martin`s HELIOS DEW.

DEWs

A directed energy weapon works on the principle of an intensely concentrated energy aimed at neutralising targets at a particular range, but without solid projectiles. In simple terms, DEWs destroy targets using focussed energy. Some of the common DEWs are:

- Railgun: this linear motor equipment uses electromagnetic force to fire high velocity munition and was designed to look like a weapon.
- Laser weapon: also referred to as a dazzler, this laser uses a high-power beam to destroy targets. Its intense energy travels over long distances.
- Microwave weapons: energy conversion takes place from a power source, which can be a military vehicle engine or even an electrical wall socket, into radiated electromagnetic energy, which focusses on the target. This offensive weapon attacks electronics and equipment, thereby limiting human collateral.

Weapons at Sea

Lockheed Martin's 60 plus kW-class High Energy Laser and Integrated Optical-dazzler and Surveillance (HELIOS) system is the first tactical laser weapon system to be integrated onto ships and provide a directed energy capability to the fleet. According to the company's press statement: "Integrated and scalable by design, the multi-mission HELIOS system will provide tactically relevant laser weapon system warfighting capability as a key element of a layered defence architecture." According to a statement from Rick Cordaro, Vice President of Lockheed Martin Advanced Product Solutions, "HELIOS enhances the overall combat system effectiveness of the ship to deter future threats and provide additional protection. HELIOS represents a solid foundation for incremental delivery of robust and powerful laser weapon system capabilities."

Hailed as a game-changer, HELIOS, which is still under development, provides extra protection for the fleet owing to its low-cost per kill, speed of light delivery and precision response. Part of Lockheed Martin's HELIOS is an Optical Dazzling Interdictor, Navy (ODIN), designed to daze and befuddle drones as the name suggests, installed on the US Navy's ARLEIGH BURKE class guided-missile destroyers, poised to fully protect warships from airborne threats, such as anti-ship missiles.

Other weapons at sea include the above-mentioned railgun, which uses directed electromagnetic energy, and is capable of launching a precision offensive at hypersonic speeds, and from a long range. In addition, the US Navy concluded their Technology Maturation Laser Weapon System Demonstrator (LWSD) demo against an Unmanned Aerial Vehicle (UAV), in 2021.

Other Weapons

A US Armed Forces Research Laboratory (AFRL) product for the US Air Force, called Tactical High-power Operational Responder (THOR) makes use of concentrated microwaves to neutralise drones. Capable of knocking out swarms of drones, the portable THOR, though still at the prototype stage, performs silently, using radio wave bursts to target enemy UAVs and drones from long ranges.

Destined for the US Army, the Directed Energy-Manoeuvre Short-Range Air Defence (DE M-SHORAD) system is a laser-based land DEW designed to intercept and neutralise mortars, artillery and rockets. The system, a joint effort by Northrop Grumman and Lockheed Martin, and known as a Self-Protect High Energy Laser Demonstrator (SHiELD), is also meant for the US armed forces, though is still under development. SHiELD is a laser-based DEW being developed for use against surface-to-air and air-to-air missiles as a countermeasure on fighter aircraft.

Raytheon has developed directed-energy systems for the US armed forces. Raytheon's PHASER system, which is both a high-power microwave weapon and High Energy Laser Weapon System (HELWS), has demonstrated capability in shooting down UAVs. While the HELWS is effective against individual targets, the PHASER is considered to be more suitable against swarms.

DEW Developers

There are a number of global defence industries currently specialising in DEWs, including Lockheed Martin, Raytheon, Northrop Grumman, Rafael Advanced Defence Systems, the Boeing Company, MBDA, Rheinmetall, and BAE Systems.

Graphics: Lockheed Martin

Developed by Lockheed Martin, ATHENA is a ground or ship-based transportable laser system with 30 kW output.

For over four decades, Lockheed Martin has been researching and developing a laser weapon that offers the advantages of speed, flexibility, and precision at a low cost-per-engagement compared to traditional kinetic energy solutions. Lockheed Martin's Layered Laser Defense (LLD) weapon system is a result of robust systems engineering combining the most agile architecture for modularity and scalability. The company's communications team make it clear in their statement: "Building on a strong history of combat system engineering and radar excellence, our laser weapon systems enable our customers to adopt a multi-domain defensive approach."

Lockheed Martin further boasts of its integrated MORFIUS system, which has been rapidly developed and tested in labs with flight demonstrations proving its performance and capability. MORFIUS is a reusable, high-power microwave-based interceptor for C-UAS and C-swarm scenarios. This compact airborne system provides extended range and an onboard seeker to help relieve sensor requirements for expeditionary systems, allowing it to be compatible with various defence service architectures. MORFIUS can be tube-launched from an air, ground or an on-the-move vehicle platform, supporting a layered defence approach as a force multiplier in the integrated air and missile defence area.

Israel's Rafael Advanced Defense Systems is the developer of the new and successful IRON BEAM laser interception system, which is cost-effective at USD 3.50 per shot. This is the world's first energy-based weapons system able to shoot down incoming mortars, rockets and UAVs using a laser.

French defence manufacturer MBDA has been carrying out extensive research and development with respect to high-energy laser weapons systems.

India

The Indian Government-owned Defence Research and Development Organisation (DRDO) has been developing its own 'Star Wars' like programme for almost two decades; this DEW project is called ÁDITYA, which has high intensity lasers, able to engage in crowd control, intercepting incoming missiles and laser dazzlers. These DEWs are being developed by the Hyderabad-based Centre for High Energy Systems and Science (CHESS), for the Indian armed forces, along with another laboratory called Laser Science and Technology Centre (LASTEC).

In 2019, in his speech to the 12th annual Air Chief Marshal L.M. Katre memorial lecture, Head of DRDO, Dr. G. Satheesh Reddy said, "DEWs are extremely important today. The world is moving towards them. In this country too, we are carrying out many experiments. We have been working in this area for the past three to four years to develop 10-kW and 20-kW weapons."

DURGA-II

India's highly classified project – the Directionally Unrestricted Ray-Gun Array, better known as DURGA-II - has been in the works since the early 2000s, though it has made little headway over the past two decades. In 2017, a 1 kW truck-mounted laser weapon test was carried out in the presence of the then Indian Defence Minister, the late Arun Jaitley. The classified DURGA-II project is a 100-kW lightweight DEW, meant for the Indian Army, which can be integrated with air, sea, and land-based platforms.

Reportedly, the Kilo Ampere Linear Injector known as KALI, is another classified system jointly under development by DRDO and Bhabha Atomic Research Centre (BARC), intended for intercepting long-range missiles. KALI, which is basically a linear electron accelerator, is activated once a missile launch is detected, and supposedly emits powerful pulses of Relativistic Electrons Beams (REB) which destroy onboard electronic systems. KALI was first proposed by the then-BARC Director Dr. R. Chidambaram in 1985.

When questioned in the Indian Parliament in 2015 about the highly classified KALI 5000's induction into the Indian Armed Forces, the response by former Defence Minister Manohar Parrikar was that the information was "sensitive in nature".

Former Naval Chief Adm. Karambir Singh (retd) says, "[the] Indian Armed Forces are well on track as regards DEW. CHESS has developed these as anti-drone weapons. The Navy is also fitting them on board for trials, specifically to resolve stabilisation issues. In naval combat, DEWs will prove useful as anti-drone, anti-small craft and later as anti-missile terminal defence. On board ships, DEWs have yet to be operationalised, but USS PORTLAND has been fitted with a 30 kW laser."

Nations Developing DEWs

The US has taken the lead in researching and developing DEWs in a bid to utilise them as a counter to various munitions.

Other nations actively engaged in the acquisition of military-grade DEWs include the UK, Germany, France, Russia, China, Israel, India, Pakistan, Turkey, and Iran. There are reports that Iran and Turkey already have DEWs in active use, so much so that Turkey has claimed a kill with its laser weapon designated ALKA. As per unconfirmed reports, Russia is said to have become the world's first military to use laser weapons and hypersonic missiles in the current conflict against Ukraine.

Israel and France, reportedly, have plans to install laser-based DEWs on board their surface ships for air defence applications.

China, on the other hand, has successfully tested a tactical laser system with a strong resemblance to the US Navy's Laser Weapon Systems (LaWS), which is an anti-air, anti-surface defensive weapon system. There are reports regarding Chinese PLA fighters (J-20 and J-15), which are likely to have airborne laser pods mounted.

Advantages of DEWs

DEWs have a comparative advantage over conventional weapons as they are silent

Photo: Rafael

IRON BEAM is a 100kW class High Energy Laser Weapon System (HELWS) designed to intercept RAM and UAVs from a distance of a few hundred metres to up to several kilometres.

and almost invisible to the naked eye, meaning they can be used covertly. Flexibility, intensity, lethality, and delivery at the speed of light, which is around 300,000 km/s, are other qualities, which give DEWs an edge over conventional munitions, a capability which enables them to engage multiple targets simultaneously. The ability to fire at extended ranges beyond the line of sight, with precision, whilst unaffected by external atmospheric factors like wind and gravity offers them the added advantage of firing on a flat surface.

As opposed to conventional projectile weapons, which have limits regarding the amount of physical supply of ammunition and armament, DEWs are able to fire non-stop as long as there is power supply, which not only cuts costs, but also makes them a cheaper option.

Challenges

Atmospheric conditions such as the disbursal of atmosphere over distance, retention and diffraction, all have an effect on energy-based equipment, by lowering their range. Temperature maintenance at safe levels is what determines the reliability of these complex systems. This is an immense challenge since numerous technologies emit high levels of heat during operations.

A reliable and stable power source is the key to the smooth functioning of a DEW, which poses a specific challenge. Weight and size constraints too can cause restrictions especially when mounted on platforms.

DEWs like laser beams might occasionally be influenced by external factors such as dust, water vapour, or other airborne particles. Other energy solutions like radio waves can also face absorption issues.

Health Hazards

There have been reported cases of skin ailments such as burns, blisters, and pain caused to volunteer military personnel in trials. Electromagnetic waves are capable of penetrating and accessing the dermal layer of the human skin thereby causing damage. To tackle serious health hazards, a United Nations (UN) protocol -"Protocol on Blinding Laser Weapons," was signed in 1995, whereby all signatory nations agreed against development and usage of offensive laser weapons that could cause permanent blindness among civilians and combatants. There are international laws aimed at preventing weapons that cause cruelty and unnecessary harm in war.

Future

The directed energy market is growing rapidly. According to statistics, the market is expected to exceed USD 5 billion worth of business in the near future. With conventional conflicts fast moving towards non-contact warfare, factors such as removing threats at high speeds, with precision and accuracy, and at a low cost-per-engagement, seem to be driving the dynamics of the battlefield. From a strategic, operational and tactical point of view, DEWs are the weapons of the future. With aerial dogfights likely to become obsolete in the coming decades, strategic superiority over adversaries will be determined by effective use of DEWs, fully developed to engage incoming aerial threats. With combat also moving towards the space domain, DEW technology with very long-range and speed of light, will probably prove to be significant for future space combat.

Equipment for Combat Swimmers

André Forkert

Combat swimmers (frogman, combat diver/swimmer, or Navy Seal) are special forces specially trained for combat both in and under water, or who move across water to carry out missions on land.

Combat swimmers are easily distinguishable from engineer divers, as well as amphibious special operations units, such as the German Kommando Spezialkräfte (KSK) or the US Delta Force as they deploy on boats. Notably, in the area of personal equipment, there are actually few new trends, or solutions to report, though constant developments have been made. Overall, however, it can be said that rebreathers are becoming more and more compact and are also being combined with breathing gas monitoring systems (e.g. the MULTISCAN GAS analyser from Siel). They are used for safety during the dive and function as a dive log. The latter in particular are gaining ground with a tactical information background. German company Niebergall has advanced radioluminescence for military applications, in this case dive equipment displays. These are now readable even in the dark and do not have to be illuminated first. The SEAL Mk 1 Pro from Italy is the most compact and lightweight oxygen closed circuit Underwater Breathing Apparatus (UBA), designed and manufactured by Siel for shallow water and short and medium duration missions.

The Approach

The approach in or over water plays one of the most important roles. It is often the start of an operation - exceptions are via air, by helicopter or deployment by parachute. Sillinger from France offers, inter alia, the SRD (Sillinger Rapid Deployment) SUB inflatable boat. The concept of the rapid deployment boat (lengths between 3.80 to 5.25 m) enables the emergency services to recover it quickly – either from the ground or from a submarine or to lay it on the ground for camouflage. It is fully inflatable within 45 seconds thanks to an automatic system - with a filled scuba tank. In total, it takes around five minutes to deflate completely and sink the boat to the bottom, or in the same time to raise it from the bottom (from 15 m) into operational readiness. Although the engine is encased and watertight, a dry bag for the engine has now been added as a new development. Even without this, the

Photo: André Forkert

Sillinger SRD (Sillinger Rapid Deployment) SUB inflatable boat.

Photo: Sillinger

Small Sillinger boat on the Maritime Craft Aerial Delivery System (MCADS) ATAX.

Author

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Photo: SOAL Marine

The KRAKA JET BOARD is available in three sizes.

engine can be lowered to the ground at a maximum of 15 metres. It has been in use in France for about seven years. The payload is said to be 900 to 1,600 kg, depending on the length of the boat.

Inflatable Boats

In order for inflatable boats to be transported and dropped by air, there are so-called Maritime Craft Aerial Delivery System (MCADS). Sillinger works closely with IrvinGQ, for example, who offer the ATAX Marine airdrop platform or PRIBAD21.

Currently, the German Special Forces are looking for a new river combat boat (River Rhine boats, brown water boats) capable of being used in the context of military evacuation operations, as well as for tactical deployment and direct support of special forces. In this regard, a procurement is due to be implemented, together with the Army's Engineer Corps. Until then, the KSK has a smaller 6-man inflatable boat at its disposal. For this, the extraction equipment for air transportability is to follow.

On 22 June, the Budget Committee of the German Parliament discussed the procurement of new "medium-range operational boats for the Naval Special Forces Command". The procurement can now be initiated. The boats can be picked up and carried by F126 class frigates and the task force supply ship, replacing the obsolete RHIB H1010. Nine boats are due to be procured with an option for a further three. The first boats are scheduled for delivery in early 2025. The contractor is Boomeranger Boats from Finland.

The UK's Special Boat Service (SBS) commandos are testing a new armoured craft capable of 50 knots. The high-speed STORMBLADE from BAE Systems can carry up to six commandos and is unsinkable with its self-righting hull. The SBS will use it in anti-terror operations on the UK's rivers.

Another platform is the K50 from the Start-Up Kraken, which should be launched by the end of 2022. The KRAKEN K50 is a built-for-purpose, ultra-high performance maritime platform, capable of rapid response and massive solo or swarmed force projection in defence of national or naval maritime assets, sovereign waters and critical civil or commercial infrastructure. Inspired by the efficacy and naval doctrine options enabled through the use of heavily weaponised, swarm-based, planning powerboats of the WW2 era, the KRAKEN is every inch the spiritual successor to the renowned MTB, MGB and PT Boat type craft. Engineered from the keel up as a fully integrated weapons platform to exceed anything currently available, the KRAKEN K50 simply delivers more performance, more effective strike capability and more mission-specific customisation. This combination of innovative engineering, diligent naval architecture, and massive operational capability makes the KRAKEN equally effective in both deterrent and effector roles. The KRAKEN K50 is available in two variants: K50A and B. The K50A is the fully equipped and definitive maritime precision engagement craft, complete with weaponisation and unsurpassed performance envelope. The K50B addresses the interdiction, interception and fast patrol needs of navies, border forces and law-enforcement agencies. Drawing on the same engineering philosophy, innovative mindset and able to be equipped to varying degrees to meet specific scenarios, the K50B provides extraordinary performance and appropriate levels of weaponisation in conjunction with unprecedented mission-specific customisation opportunity.

The inflatable and electrically powered KRAKA jet board is a much smaller vessel, recently developed in Sweden. It is very light and small, taking up little space, so it can be easily packed into a small drop container or carried in a submarine's torpedo tubes when deflated. It takes less than three seconds to go from packed to fully inflated ready for use, according to manufacturer SOAL Marine. The KRAKA then provides the user with a simple, low-


Photo: André Forkert

The Tactical Water Craft X3.

Photo: André Forkert

The SUEX Scooter can pull up to four divers or heavy equipment. The DPD transport frame is only for easier transport into the water and is left behind on the beach.

signature method of transportation to the deployment site. The KRAKA can most readily be compared to an inconspicuous inflatable boat. These alternatives offer more or less the same operational advantages but differ in size and airdrop capability. The KRAKA is produced in three sizes and with different orientations: transport, air and dive. The device is well suited for SAR, combat swimmer and infiltration operations. The board is made of lightweight composite and inflatable materials and is built to last. The 11-KW brushless electric motor can carry two commandos and equipment at speeds up to 20 knots. Maintenance requirements are said to be minimal. The battery powers the propulsion system for 30 to 60 minutes, depending on speed and load. Additional batteries increase the range. In addition, the KRAKA can be towed by other boats or watercraft, such as jet skis. There are three sizes in six variants, each for a payload of 250, 400 or 600 kg. In each of the three sizes, the KRAKA is available as a sled vehicle without propulsion and as a full KRAKA with the aforementioned electric motor. Then there is the optional modification for use as a transport, airdrop or dive.

One of the most vulnerable parts of inflatable boats are the outboard motors. One lucky hit and the propulsion can fail, meaning the boat becomes an easy target. That's why Falcon Dynamics and its Swedish partner Equipnor AB have developed ballistic protective covers for outboard motors. These are specially adapted for each engine and thus protect them from small arms fire.

Photo: André Forkert

Military kayak by Wayland from Poland with a prototype of an all-electric and silent auxiliary propulsion system.

Electronic Defence Systems

As radars, thermal devices and electronic defence systems become more readily available to a larger audience, Swimmer Delivery Vehicles (SDV) become increasingly important to ensure a covert approach. The other important tool for reconnaissance, impact and support are Unmanned Surface Vehicles (USV).

One of the latest SDVs is the SHADOW SEAL, designed by Filip Jonker and JFD Ortega Submersibles from the Netherlands. The SHADOW SEAL can transport four fully equipped operators and 450 litres of payload. It offers a supreme roll stability and can be operated even in rough seas. The SHADOW SEAL is constructed for both over and (semi) underwater transport, with two high-power electric motors. It is equipped with closed-loop trimming tanks, bow and trim thruster, underwater navigation system, onboard suit heating and CCR compatibility.

Golden Arrow Marine offers a jet ski for military operations. A civilian SEADOO is used as the basis, which is adapted according to customer wishes. This turns the COTS into a MOTS, which is called the Tactical Water Craft X3. It is given a collar or tube on the outside, which provides increased stability and absorbs shocks when boarding or picking up people from the water. In addition, the jet ski has four lifting points (for picking up/dropping off ships or helicopters), two additional tank pockets to increase the range, protectors on the control handles, which can also be heated against the cold, integrated (military) GPS, pull cord at the rear for loads, etc. The unladen weight of the jet ski is also reduced. The empty weight of the jet ski is 400 kg, and it can travel faster than 75 mph. There are already several global and NATO users.

Scooters

Italian manufacturer SUEX offers a wide variety of scooters for diving depths of up to 200 m. By combining several scooters into one system, up to four divers or heavy loads can be pulled over long distances without a problem.

Rotinor from Germany offers the SEABOB BLACK SHADOW 730 (RBS) and the smaller DiveJet RD2. Both can be deployed via the torpedo tube of a submarine or deployed by parachute. They can be controlled down to a depth of 60 m and are thus ideally suited for all kinds of underwater missions and special operations. The hydrodynamic design of the RBS gives the diving scooter a high degree of agility in the water. All steering and diving manoeuvres are performed simply by shifting the weight of the body. The specially developed harness system allows the operator to easily control the enormous thrust of over 70 kg. It is powered by an e-jet motor. For deployment by parachute, ATASS Advanced Tactical Airborne Systems and Services GmbH offers the TRIDENT and TRITON harnesses from Paratec. These special harnesses enable maritime special forces to personally and safely transport submersibles to any desired location by vertical deployment. The TRIDENT harness consists of a large bag, which includes the harness itself, the grid board, the roller unit and the lowering device with V-connections, friction plate with centre strap and a lowering line. Both harnesses can carry a payload up to 115 kg. One of the demands made during the SOF-IC exhibition in Tampa, Florida, was that US Navy Seals receive upgrades for their silent underwater rides. Many systems currently in use are in urgent need of replacement or an upgrade to be ready for future challenges.

Photo: Ghotshood

Project TRIDENT provides camouflage for operations in water and on land.

Photo: ATASS

Rotinor BLACK SHADOW can be transported by parachute thanks to a special harness.

Frogmen do not always move over or through the water. Often, vertical deployment is their means of choice. Therefore, all fittings on the parachutes are made of seawater-resistant special steel. Otherwise, they are subject to special rinsing procedures after water jumps, which ensures that all residues are flushed out of the fabric. Some manufacturers are also developing harnesses that can accommodate rebreather devices, for example. Moreover, the military CYPRES 2, and the SLS (Static Line Cypres) are fresh and salt water resistant. Both offer 24-hour water resistance to a depth of 2.5 metres. This means that they can be reused after training and mission jumps – if the extraction/exfiltration is carried out by their own boats.

Individual Equipment

With the TRIDENT project, German camouflage specialist Ghosthood has developed a solution especially for use in water. The solution was developed together with EU/NATO units and is currently being tested by special forces in the USA. The material can be used as camouflage both in the water and on land. After landing on the beach, the camouflage then functions like a ghillie suit. Currently, this solution is available in five different camouflage patterns. The material is a mix, the largest part is a very light but strong fabric that does not absorb water and thus does not become heavier. It is reinforced in particularly stressed areas, for example as protection during extraction from a submarine. Lastly, the rebreather cover has been revised and is now completely laser-cut and can accommodate pockets on the outside. A camouflage cover for the Rotinor scooter is also offered to protect it against reconnaissance on land. In the future, a camouflage cover will be developed that can also be used during the dive.

For maritime special forces, many items of equipment also need to be submersible to 20 m or more. That is why all-night vision optics from ACT in Black from Belgium are designed to be waterproof up to 20 metres. They are designed that way from the start, so special seals and only rustproof material are used. Nothing is glued, however, so the system remains maintainable.

At Aimpoint, all military optics are submersible to 25 or 40 metres.

The tactical noise protection headset systems from Silynx are also designed for swimming and diving. The Fortis TRIO and Clarius FX systems are submersible to 20 m and for 30 minutes. The in-ear headset is submersible only to 1 m and for 30 minutes so the systems can be put on before surfacing.

For sensitive equipment, Peli offers the RUCK series and its R20/40/60, three small transport and protection solutions that are IP68 protected and submersible. They primarily serve as protection for smaller sensitive devices and personal equipment. A pressure equalisation valve is built in.

A new buoyant and submersible bag/backpack series is to be procured for the German Special Forces (KSK and KSM). Older systems are to be replaced with MOTS products.

With the SHADOW AMPHIBIAN, HYDRO RECON (with neoprene) and RAPID ASSAULT, US shoe manufacturer Lalo offers several products for Navy Seals. The aim is to move from air to sea to land without changing footwear. The shoes have a slip-resistant and stable sole (so that narrow ladders can be used when boarding), dual direction drainage ports and some have fin clips.

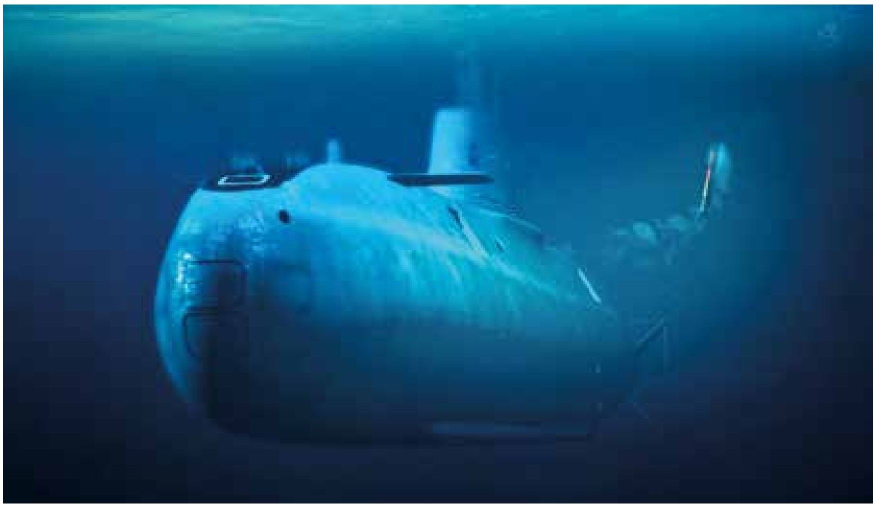
Sabotage & Reconnaissance

EvoLogics GmbH offers the SONOBOT 5 (H/W/L: 805x920x1,300 mm, 27 kg), an autonomous hydrographic survey vehicle. It can be used to check rivers or beaches and harbour sections before landing, waterway crossings or objects in and around the water. The sea drone offers single-beam echosounder, multibeam echosounder, side-scan sonar and an HD camera. In silent mode, the vehicle automatically performs predefined missions with the radio

Photo: André Forkert

The unmanned surface RECCE-drone SONOBOT 5.

Photo: SpearUAV



The capsulated NINOX 103 UAS can be started underwater from a submarine.

switched off. The Dutch police and the Swedish military are already using the system, and the German military engineering force is currently introducing it.

UAS

SpearUAV developed the encapsulated NINOX 103 Sub-to-Air loitering UAS, which enables the launch of submerged drones into the air for the first time, thereby providing immediate beyond-line-of-sight situational awareness. Designed for undetectable, underwater launch, and focusing on existing operational needs, the NINOX 103 Sub-to-Air is an autonomous AI-based system. Intuitive and easy to operate, it provides the most effective way for submarines, Autonomous Underwater Vehicles (AUVs), other underwater platforms, or surface boats. As it can also be started manually, it can also be used by divers. Capable of immediate launch, the system enables the boat team or diver to receive real-time imaging beyond the coastline, at long ranges, while remaining undetected and at a distance from land. Ruggedised for harsh underwater and maritime environments, the NINOX 103 is payload agnostic, with open architecture that enables third-party data link integration. Seamlessly integrated into existing submarine launching infrastructure, its low visual, thermal and acoustic signatures support stealth-mode operation.

Libervit from France offers the BLACK-LINE M3863/64/65 series of hydraulic underwater breaching and spreading tools for rescue operations or creating access underwater. It can be used autonomously up to a depth of 80 m without support or wiring to the water surface. The system consists of a submersible power source, a motor and the hydraulic tools. The tools can be changed underwater and are used for prying, spreading, lifting or cutting; moreover, the system has neutral buoyancy. The "Thermic Torch" is used for burning or welding under water with the technology based on a flame that reaches temperatures up to 5,000°C, generated by pure oxygen and electricity, thus making underwater welding possible. Innovations were presented at 2022 Eurosatory exhibition. The "pushing ram" can develop a compressive force of 18 tonnes. This means that underwater obstacles can be pushed up or apart. For example, the drive shafts of ships to make them unusable without sinking them or attracting attention through an explosion. The defect is only noticed when the ship wants to set off again. The same applies to the "pulling ram", only here it is pulled instead of pushed apart. Two rams can also be combined. The so-called "clamp" can damage a ship's propeller due to pressure. Due to the resulting imbalance, it will report a defect to the system during next use or lead to an overload and a defect in the drive train. All three new options have neutral buoyancy already integrated and do not require an additional system.

Head-Up Displays

To keep your hands free for such work or for steering an underwater scooter, Scubapro Professional Services has developed the GALILEO HUD PRO (Head-Up Display). The HUD includes a full-fledged dive com-

Photo: SpearUAV

The NINOX 102 UAS can also be started manually by a frogman.

Photo: André Forkert

The submersible BLACK-LINE system from Libervit. In the background of the hydraulic underwater breaking and spreading tool ONE can see the power supply with integrated motor.

puter with all common functions, attached directly to the diving goggles. This means that the diver no longer needs to pay attention to the display on his arm but has all the information constantly in view. The settings are adjusted via a single button, and if necessary, the HUD can be folded away upwards. Besides the display regarding the remaining air level, it also offers navigation via GPS and an underwater compass. The GPS only works on the water surface, but underwater waypoints and their direction are displayed in relation to the last-known coordinates. A GPS signal can also be picked up from external antennae (e.g. on the water surface, vehicles, etc.). In the "Combat Swimmer" (Navy) mode, all waypoints can be deleted at the touch of a button, and three different data views (dive information such as depth and dive time, dive information & navigation, including compass and waypoints, and a summary with time, max. depth, water temperature, battery indicator) are provided specifically for combat swimmer operations.

The HUD can be retrofitted to any diving mask. For better readability, the displays (colour OLED with 96x64 pixels) are shown virtually at a distance of 1 m, so the eye does not need to refocus during the dive. The dive computer can be used for diving with compressed air, Nitrox, Trimix, Multi-Gas (up to eight Trimix gases) and rebreathers (CCR). Data can be stored or read out via a USB port. According to the manufacturer, the diving depth is 120 m, battery life up to 20 hours, with charging taking two hours via USB. ■

Sea Change for the LCS?

Littoral Combat Ship Faces New Uncertainty

Sidney E. Dean

The US Navy's controversial Littoral Combat Ship (LCS) has entered a new phase of uncertainty. Initially praised as a Swiss Army Knife for the fleet, capable of quickly switching between multiple roles, the LCS's performance to date has been disappointing.

The Pentagon has decided to drastically cut the LCS fleet, while adapting the remaining vessels' mission profile. Congress – which has the ultimate authority in such matters – may block a portion of the planned force reduction.

Procurement

Littoral Combat Ship procurement began in 2005 with the goal of acquiring fast, manoeuvrable small surface combatants optimised for near-shore environments. Initial plans called for 55 vessels, to be split nearly evenly between the FREEDOM class (LCS-1, developed by Fincantieri/Marinette Marine using a double chine semi-planing monohull) and the INDEPENDENCE class (LCS-2, developed by Austal using an aluminium-hull Trimaran form). Constructed with a minimum of permanent on-board operational systems, each ship was to be outfitted as needed using mission modules optimised for Surface Warfare (ASuW), Mine Countermeasures (MCM), and Anti-Submarine Warfare (ASW).
Problems plagued the LCS programme from the beginning, including delays in delivery and operational certification, significant mechanical and structural defects, and late completion of key mission modules. It also became evident that the Navy's intent to regularly reconfigure each vessel to meet changing operational needs was not practical. The mission-modularity concept was finally scrapped in favour of permanently dedicating each ship to one of the three primary mission types. The Navy has also repeatedly reduced its LCS procurement goal, with a target of 32 ships being set in 2016, increasing again to 35 in 2019.

Current Technical Issues and Readiness

While the early technical defects have been resolved, new ones continue to appear. In

Photo: US Navy

Speed, manoeuvrability and the ability to operate in coastal waters and archipelagos as well as at sea make the LCS well suited for interdiction patrols.

Photo: US Navy

SIOUX CITY (LCS 11) is the first LCS to be deployed to the Mediterranean and to the Middle East.

late 2020 a serious design flaw was discovered on the FREEDOM class's propulsion system. The combining gear connecting the gas turbines and the Diesel engines is subject to breakdown. Failure to engage the gas turbines limits operating speed to 12 knots, making the vessel unsuitable for conflict zones. A redesign of the gear system was devised by late 2021 but implementing it on completed ships is costly and time consuming. Units which have not received the fix are still classified as deployable, but with limitations.

The INDEPENDENCE class has its own problems. In early 2022 the Navy reported that hull cracks had been detected on at least six vessels but downplayed the significance since the cracks were above the waterline. This issue, which impacted the vessels over a period of years, was determined to be a design defect "in the higher stress areas of the [ships'] structure." A Navy spokesman stated in May 2022 that Austal had introduced a revised configuration to mitigate the defect, including replacing deck and shell plates with thicker materials. In the meantime at least one effected vessel was restricted to speeds below 16 knots and operational conditions below sea state 4.

Mission Module Status

While the first LCS were commissioned in 2008 and 2010, and the fleet currently consists of 23 units, the ship type has made few operational deployments to date. This is slowly changing, with several missions by INDEPENDENCE class vessels to the western Pacific since 2019. A FREEDOM class vessel conducted the first LCS operational deployment to the Mediterranean and to the Persian Gulf in 2022.

Aside from reliability issues of the ships themselves, this slow deployment cycle is largely due to delayed development of the mission modules. Common mission systems on all LCS are basic, and include a 57mm gun, .50 calibre machine guns, a point-defence system (RAM or SeaRAM) and the ALEX decoy system, as well as one MH-60 class manned helicopter and one MQ-8 FIRE SCOUT Vertical Takeoff UAV (VTUAV) equipped for Intelligence/Surveillance/Reconnaissance (ISR) missions.

Surface Warfare

The surface warfare mission module was certified as fully operational on both LCS variants in 2019. Ships configured for the SUW mission receive two 30mm guns, a surface-to-surface missile module with 24 AGM-114L HELLFIRE LONGBOW missiles (range: eight km), and 11 metre RHIBs for

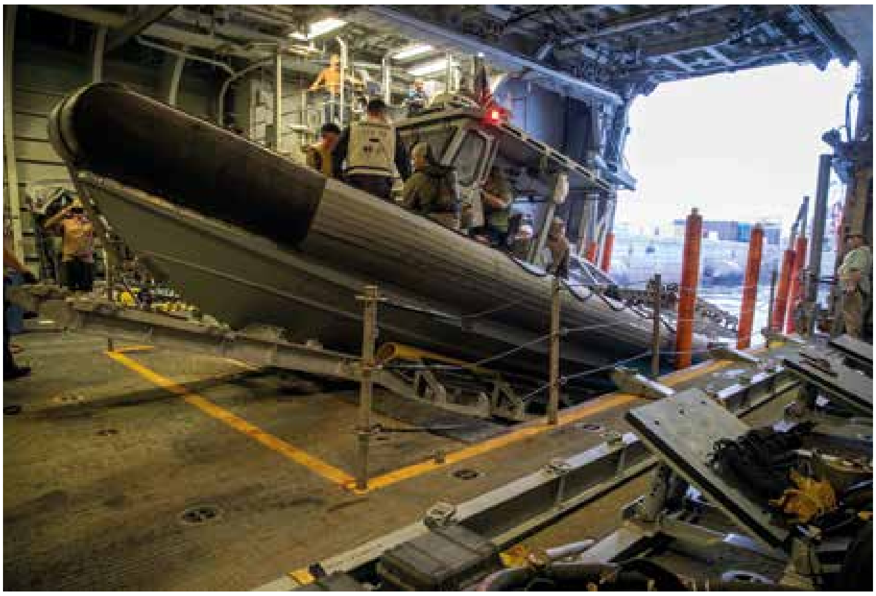


Photo: US Navy

Sailors practice conducting MCM aboard a rigid-hull inflatable boat with sailors aboard the FREEDOM-variant littoral combat ship SIOUX CITY.

Photo: US Navy

Deploying independently, LCS can demonstrate forward presence as well as perform ISR missions and maritime security patrols against moderate-level threats including fast attack craft.

Photo: US Navy

Since 2019 LCS have been executing rotational deployments to the western Pacific.

Photo: US Navy

The large mission bay and well deck of the INDEPENDENCE class lends considerable flexibility and facilitates deployment of USVs and UUVs.

Photo: US Navy

Both LCS classes deploy the MQ-8B FIRE SCOUT UAV as an over-the-horizon ISR and targeting asset.

Photo: US Navy

The standard 57mm Mk 110 gun has a 220 round-per-minute rate of fire.

maritime interdiction. The ship's MH-60R helicopter is also armed with HELLFIRE missiles. The module's missiles can defeat swarms of high speed attack craft or be deployed against coastal targets as fire support for amphibious forces.

The Navy will expand the ASuW package to include an over-the-horizon weapon system consisting of eight Kongsberg NAVAL STRIKE MISSILES (NSMs) with circa 100 NM range, adding a potent weapon against high-end enemy warships. In autumn 2021 three INDEPENDENCE class LCS bearing NSM launchers deployed to the western Pacific.

Mine Counter-Measures

The MCM package contains airborne and waterborne systems: a manned MH-60S helicopter equipped with the Airborne Laser Mine Detection System (ALMDS) and the Airborne Mine Neutralization System (AMNS); a MQ-8 FIRE SCOUT bearing the Coastal Battlefield Reconnaissance and Analysis (COBRA) system; the KNIFEFISH unmanned underwater vehicle deployed directly from the ship; and the Unmanned Influence Sweep System (UISS) consisting of the MCM unmanned surface vehicle towing acoustic and magnetic minesweeping systems. The three airborne elements of the MCM module are certified as operational and have already been deployed, while the surface and subsurface elements are undergoing testing and integration. In May 2022, Chief of Naval Operations Admiral Mike Gilday stated that the complete MCM package is expected to achieve initial operational capability "either late this Summer or in the Fall, but within the next year."

Anti-Submarine Warfare

In March 2022 the Navy announced that it would cancel development of the Anti-Submarine Warfare mission module and eliminate ASW as an LCS mission. The mission module was designed around a towed variable-depth sonar or VDS which was to be optimised for detection of Russian and Chinese submarines. Development of the VDS was years behind schedule, with prototypes demonstrating very poor performance. ASW operations will now become a major mission for the CONSTELLATIOON class frigates which are due to enter service circa 2030.

Force Structure Changes

In March 2022 the Navy also announced the decision to retire all nine extant FREE-


Photo: US Navy

The Kongsberg NAVAL STRIKE MISSILE endows the LCS with a long-range offensive capability against high-end warships.

DOM class vessels in 2023. The decision is controversial as the ships in question, which have a planned 25-year service life, were only commissioned between 2012 and 2020. Another six ships of this class were under construction when the retirement decision was taken (one of them has since been commissioned). Current plans call for completion and retention of those begun hulls, all of which will receive the improved propulsion gear system; according to Navy sources, they will be equipped with the ASuW module and deployed in Caribbean/Latin American waters and in the Middle East.

According to Admiral Gilday, the cancellation of the ASW mission package – which was to have been exclusively operated by the FREEDOM class – was the decisive factor. Without the ASW capability the vessels "just didn't bring the warfighting value to the fight," Gilday testified before Congress on 26 May 2022.

By contrast, the Navy plans to retain its full complement of INDEPENDENCE class LCS, of which 13 are currently in service, with another five under construction or in pre-production. Together with six ASuW-equipped FREEDOM class ships, this will provide the Fleet with 24 LCS.

New Mission Concepts

The original LCS concept had its roots in the experience of Operation Desert Storm (1990-1991) which initiated a post-Cold War focus on littoral operations. Today the Navy is charting a similar course change to reflect the return of great power conflict. While the LCS will continue to serve a broad spectrum of missions, including partnership and training programmes as well as drug and piracy interdiction, the fleet is now being evaluated for the contribution it can bring to a high-intensity campaign. Operating independently, LCS could conduct ISR missions and conduct distributed offensive operations with the NAVAL STRIKE MISSILE. In formation with other vessels, they could


Photo: US Navy

The LCS' ASuW module includes 24 HELLFIRE missiles which can be deployed against swarming boats including fast attack craft. In May 2022, MONTGOMERY became the first LCS to test fire the AGM-114L in the land attack mode, simulating fire support for amphibious forces.


Photo: US Navy

The Mk 18 Mod 2 KINGFISH UUV is an integral element of the LCS' mine warfare mission module.


Photo: US Navy

The 12-metre long Mine Countermeasures Unmanned Surface Vehicle (MCM USV), similar in size to the RHIB shown here, will be an integral element of the mine-countermeasures package which will be permanently assigned to a portion of the INDEPENDENCE class LCS.

deploy their ASuW and MCM resources for force protection.

In this context, Vice Admiral Roy Kitchener, Commander of Naval Surface Forces, told reporters in January 2022 that the Navy was testing the LCS' suitability to support the US Marine Corps' Expeditionary Advanced Base Operations (EABO) mission, which centres around mobile operations by small USMC units in the island chains of the western Pacific. Kitchener described LCS as a "very potent hull" capable of escorting light amphibious warships, clearing minefields ahead of USMC landings, and even transporting Marines and their equipment between islands.

In August 2022 Adm. Kitchener added that he would like to increase the LCS presence in the Western Pacific from currently three to six units at any given time. He specifically referenced the INDEPENDENCE class outfitted with the NSM to conduct presence operations. Citing progress in reliability of the FREEDOM class, the admiral said that the USN is also looking to formalise a deployment strategy to European and Middle Eastern waters for those vessels.

Congress Weighs In

Many members of Congress oppose early retirement of the current FREEDOM class vessels. Major arguments include the investment already made in these platforms, and the force structure gap that would exist before they could be replaced with new ships. Suggestions include deploying the FREEDOM class vessels – once their combining gear systems are replaced – for low-end missions in permissive environments, thereby freeing up more robust warships. Alternate proposals would enhance the ships' survivability and lethality by integrating additional combat systems including an electronic warfare suite and the Vertical Launch ASROC Extended Range (VLA–ER) ASW weapon.

Congress is currently finalising the 2023 defence appropriations bill. While final passage is not expected until autumn, the Pentagon has already been put on notice regarding LCS. The bill pending in the Senate and the bill passed in the House of Representatives in July 2022 both limit the Navy to retiring only four LCS in 2023. While this is still subject to change until passage of a compromise appropriations bill, the odds are strong that the Navy will retain more FREEDOM class ship than it intended to. The Pentagon may anticipate this as well. To date, two of the nine ships on the retirement list have either received the combining gear replacement, or are scheduled for the upgrade. ■

Naval Unmanned Aerial Systems

High-End Systems Join NATO Nations' Fleets

Sidney E. Dean

High-performance Unmanned Aerial Systems (UAS) are becoming standard fixtures in modern armed forces, including those in North America and Europe. The sea services are no exception.

Increasingly sophisticated unmanned systems are entering service – or will soon enter service – across the fleet structure, deploying on ships and supporting naval operations from land. This trend includes large, high endurance aircraft, which are the focus of this article.

Small Surface Combatant UAS

While large surface combatants tend to deploy with two manned multi-mission aircraft, small surface combatants or SSCs (corvettes, frigates, Littoral Combat Ship) benefit from sailing with a mix of one manned and (depending on size) one to three unmanned helicopters. The UAS deployed on surface combatants act as force multipliers and augment the manned aircraft. Utilising radar and Electro-Optical/Infrared (EO/IR) cameras, they can significantly enhance the ship's situational awareness by flying well beyond the detection range of the ship's own sensors. Their primary contribution lies with Intelligence, Surveillance, Targeting and Reconnaissance (ISTAR) missions over sea and land. This includes such functions as Search and Rescue (S&R), targeting support for over-the-horizon shipboard weapons, and battle damage assessment. While the manned helicopter can perform all of these tasks, the unmanned systems tend to have significantly better mission endurance. Especially when multiple UAS are carried, this translates to a more consistent forward presence beyond the ship sensor's line of sight.

Photo: US Navy

Refuelling an MQ-8B VTUAV aboard the Littoral Combat Ship BILLINGS. Note the Teledyne FLIR BRITE STAR II electro-optical/infrared turret under the bow.

Photo: US Navy

An MQ-8C VTUAV deployed in the western Pacific. The MQ-8C is based on the airframe of the manned Bell 407 helicopter.

MQ-8 FIRE SCOUT

The top-line UAS deployed on US Navy SSCs is the MQ-8 FIRE SCOUT Vertical Takeoff Unmanned Aerial Vehicle (VTUAV) produced by Northrop Grumman. The first variant, designated as the MQ-8B, entered service in 2009. The 9.7 metre, 910 kg aircraft will be retired in 2023 in favour of the significantly larger MQ-8C, which was declared operational in 2019. The MQ-8C's greater size (10.7 metres, 1,450 kg) translates to higher performance parameters, including a range of 150 nm. At 115 knots cruise speed and a typical 140 kg payload, the UAS achieves 4,920 metres service ceiling and a 12-hour mission endurance. The MQ-8C carries an upgraded sensor package including the Leonardo OSPREY

Photo: US Navy

Manned-unmanned teaming of an MQ-8C UAS and a manned MH-60S helicopter, both assigned to the Littoral Combat Ship JACKSON during deployment to the South China Sea.

Photo: U.S. Navy photo courtesy of Boeing

The MQ-25A T1 test aircraft refuelling an F/A-18 SUPER HORNET in 2021.

Photo: U.S. Navy photo courtesy of Boeing

The MQ-25A STINGRAY will bring refuelling and ISR capabilities to the US Navy carrier Air Wing.

AN/ZPY-8 radar which features a larger field of view and a greater range of digital modes; this significantly enhances the UAS' ability to identify, detect and track targets.

An exercise conducted in June 2022 confirmed the MQ-8C's suitability for expeditionary operations, including the ability of the shipboard UAS to temporarily operate from austere land-based locations, or to transfer at sea to operate from a different class ship. "FIRE SCOUT is the Navy's only unmanned helicopter with the ability to deploy from a ship or land with ISR&T at the extended range required for future warfighting," said Capt. Dennis Monagle, FIRE SCOUT programme manager. "The system is vital in expeditionary use for situational awareness and critical decision-making."

Airbus VSR700

Within Europe, France has the most advanced and ambitious naval UAS programmes. This includes plans to introduce an advanced shipboard UAS to augment manned helicopters aboard various frigate classes by 2029. The day and night, all weather capable Système de Drone Aérien Pour la Marine (SDAM) will have a payload capacity of 100 kg and perform ISTAR and communications relay missions in littoral and offshore environments, at distances up to 100 nm from the mothership. Current experimentation centres around the Airbus VSR700 prototype, which was tested in early 2022 from a civilian vessel.

Operating ceiling and top speed are 6,000 metres and 120 knots, respectively. Airbus cites a payload-dependent 8–10-hour mission endurance for the aircraft, which is interoperable with other NATO naval systems. In addition to standard ISTAR missions – including positive surface target identification and illumination – the VSR700 can also support Anti-Submarine Warfare (ASW) operations by relaying sonobouy data to the mother ship, and by deploying its own high-performance, long-range EO/IR sensors and radar to detect and classify periscopes. Airbus touts the advantages of the 6.2 metre long, 715 kg VTUAV's small silhouette, which reduces the aircraft's visual and radar profile, enabling covert surveillance operations.

Carrier Based UAS

MQ-25A

The US Navy's MQ-25A STINGRAY will be the world's first operational carrier-based unmanned aircraft. Its mission profile includes aerial refuelling of manned carrier-based aircraft, and ISR missions including battle damage assessment. Until now, carrier-based aerial refuelling has been conducted by a portion of the air wing's strike aircraft equipped with auxiliary external fuel tanks instead of ordnance. Adding Boeing's MQ-25A to the air wing will free up those fighter aircraft for strike missions, enhancing the overall combat power. The 15.7-metre-long aircraft can deliver 6,800 kg of fuel per flight. Each MQ-25A is expected to refuel four to six aircraft per mission, extending the fighters' operating range by at least 300 nm. Joint government/industry flight tests of T1, the first MQ-25 prototype/test asset, began in 2019. Considerable progress has been made to date, with T1 successfully integrated into the GEORGE H.W. BUSH aviation group in 2021 and conducting aerial refuelling of F/A-18, F-35 and E-2D aircraft. Testing and concept development continue. IOC is expected in late 2025.

Project VIXEN

In 2021 the United Kingdom's Royal Navy (RN) revealed the existence of Project VIXEN, which is pursuing development of fixed-wing UAVs for the QUEEN ELIZABETH class aircraft carriers. In a separate but simultaneous move the RN in 2021 issued a request for proposals regarding electromagnetic catapult and arrestor systems capable of processing aircraft up to 55,000 kg. This is widely thought to be directed at the VIXEN UAS. Potential applications for the UAS include aerial refuelling, ISR, and Airborne Early Warning (AEW). At this point, Project VIXEN is a conceptual programme. If the project is pursued to fruition, a likely IOC target would be 2030.

Land-Based UAS

Land-based naval UAS consist of aircraft which are too large for even big-deck ships. This category consists of Medium-Altitude Long-Endurance (MALE) and High-Altitude Long Endurance (HALE) systems, which are primarily used for wide area maritime surveillance missions.

MQ-4C TRITON

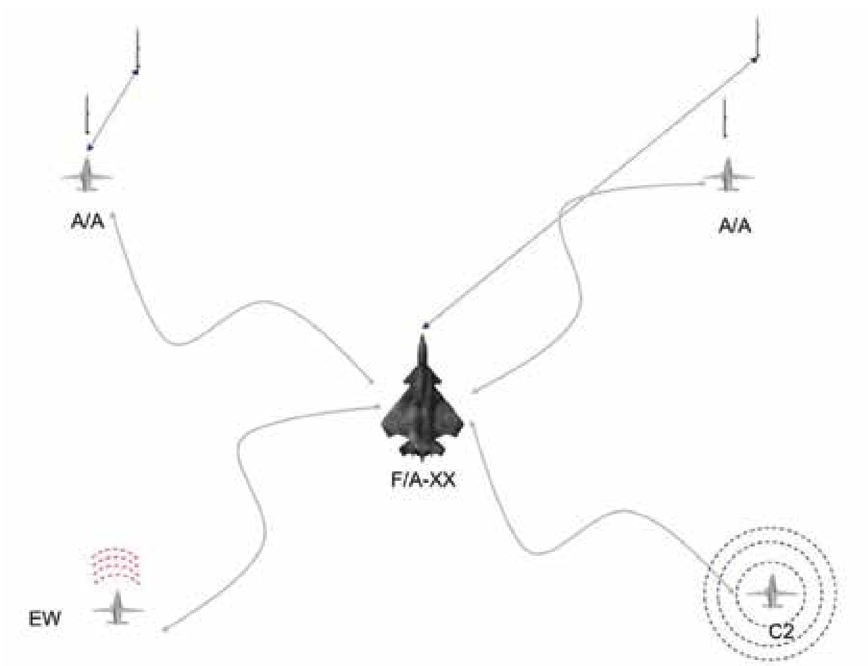
The US Navy's autonomously operated MQ-4C TRITON, developed by Northrop Grumman, provides a persistent maritime ISR with radar, EO/IR and an advanced signals intelligence (SIGINT) capability. The SIGINT capability is being upgraded

Photo: US Navy

An MQ-4C TRITON Unmanned Aircraft System (UAS), assigned to Unmanned Patrol Squadron 19 (VUP-19), lands at Naval Station Mayport. VUP-19 is currently developing the MQ-4C's concept of operations and refining tactics, techniques, and procedures prior to declaring IOC in 2023.

Photo: US Navy

The US Navy plans to deploy the MQ-4C TRITON to five orbits worldwide, providing persistent maritime ISR capabilities over all oceans.



Credit: US Navy

Concept of a future US Navy carrier based Next Generation Air Dominance (NGAD) flight. This notional configuration centres around a manned combat aircraft supported by two unmanned escorts armed with air-to-air missiles, and receiving further support from unmanned electronic warfare and command and control assets.

Credit: Airbus

Concept image of an SDAM/VSR700 UAS over a GOWIND class corvette.

Photo: Airbus

The VSR700 prototype approaching the French frigate FORBIN, lead ship of the HORIZON class.

Credit: Airbus

EURODRONE in the maritime surveillance role.

with two new sensors geared toward electronic intelligence and communications intelligence, respectively, creating the Integrated Functional Capability 4 (IFC-4) variant. All MQ-4C mission sensors have 360-degree coverage for full situational awareness.

Mission endurance of the HALE UAS exceeds 24 hours, with each mission encompassing a 2.7 million square mile area. Operational range and altitude are 8,200 nm and 16,000 metres. The 14.5 metre long, 14,600 kg aircraft has a wingspan of 39.9 metres and can only operate from prepared land-based runways. The airframe is hardened against such hazards as hail, birdstrike and lightning, and includes de-icing. The aircraft can seamlessly ascend and descend to maximise surveillance area or focus on surface targets of interest. A five-person ground crew (air vehicle operator, tactical coordinator, 2 mission payload operators, SIGINT coordinator) retains operational control. Official IOC for the TRITON is planned for 2023. Two aircraft equipped with "early operational capability" hardware and software were deployed to Guam in early 2020, and have been flying surveillance missions over the Pacific Ocean since then. Australia is also procuring the MQ-4C.

RPAS

While the United States leads in the production of HALE UAS, Europe is pursuing development of the MALE Remotely Piloted Aircraft System (RPAS), often referred to as the EURODRONE. The programme was launched jointly in 2016 by France, Germany, Italy and Spain, and is being spearheaded by Airbus, Dassault and Leonardo. The UAS will be capable of ISTAR and SIGINT missions over land and sea. The 11-ton aircraft will have a 26 metre wingspan and is expected to fly at approximately 13,500 metres. Endurance is pegged between 18 and 40 hour, depending on payload and mission profile. The development and production contract was signed in February 2022. The multinational European Organisation for Joint Armament Co-operation (OCCAR) estimates prototype production will begin in 2024, with serial production to begin at the end of the decade.

Unmanned Maritime Combat Aircraft

The next major development will be introduction of armed UAS. The. US Navy plans to introduce carrier-based, jet powered unmanned combat air vehicles (UCAV) as part of the manned/unmanned Next Generation Air Dominance aircraft family (NGAD). The UCAVs will likely be configured for Electronic Warfare (EW) as well as for kinetic attack missions against enemy air and ground targets. Tasks are likely to include escort of manned combat aircraft, Suppression of Enemy Air Defences (SEAD), and destruction of well protected targets, relieving manned aircraft from some of the most dangerous missions. NGAD is expected to enter service in the 2030s.

EW and strike mission capabilities are also being considered as part of the Royal Navy's Project VIXEN. Uncertainty remains concerning the potential airframes for carrier-based UCAVs, as the Royal Air Force (RAF) surprisingly cancelled its own Project MOSQUITO unmanned fighter development programme in June 2022. The RN's nominal VIXEN was widely expected to be based on the RAF's MOSQUITO.

Credit: UK MoD/Crown Copyright

The UK's Royal Navy Project VIXEN is investigating various unmanned carrier-based aircraft concepts, including potential deployment of unmanned escorts for carrier-based F-35s.

Credit: Airbus

The French Navy's Next Generation Aircraft Carrier (PANG) will be configured to deploy unmanned aircraft alongside manned fighters in a maritime application of the Future Combat Air System (FCAS).

Photo: Dassault

In 2016 the French Navy tested the land-based nEUROn UCAV technology demonstrator in maritime strike scenarios.

For its part, the French Navy also plans to deploy unmanned aircraft on its Porte Avion Nouvelle Génération (PANG) next generation aircraft carrier which is expected to be completed by 2038. At some point this is likely to include UCAVs to support the manned fighters of the Future Combat Air System (FCAS).

Integration of unmanned aircraft into a carrier wing remains challenging, and is being pursued incrementally by the interested parties. In 2021 the then chief of the US Navy's air warfare directorate, Rear Admiral Gregory Harris, predicted that ultimately up to 60 percent of a carrier's aircraft could be unmanned. Where the US Navy is concerned, lessons learned from the pending integration of the MQ-25 will determine the pace of future developments, Harris said.

High Speed Naval Vessels

Sidney E. Dean

While the majority of naval ships achieve top speeds well below 40 knots, some smaller vessels perform considerably better, with the fastest reaching sprint speeds around 70 knots. These high-speed vessels are primarily found among the assault craft, interceptor and patrol categories.

Assault Craft

Saab's CB90 combat boat is a global success story in the assault boat category. More than 250 units are currently in service in Europe, Asia and the Americas with the first units entering service in 1991. In October 2019, Saab began delivery of the latest iteration, the CB90NG ("Next Generation"), to the Swedish Navy which operates the new craft under the designation DOCKSTA CB90HSM. While the continuity of the CB90 family is obvious, the new vessel adds features and performance enhancements over the already impressive capabilities of the earlier models.


Photo: FMV (Swedish Defence Materiel Administration)

Saab's Combat Boat CB90 HSM, 2019.

CB90

The propulsion system consists of two 900 hp Scania V8 diesel engines and two S32 mix flow waterjets. Installation of a new driveline and relocation of the engines improve stability even during extreme turns, while also reducing acoustic signature. The boat's maximum speed is classified, with Saab only admitting to "way beyond 40 knots" (some third party sources suggest 45 knots). However, the manufacturer does confirm a cruising speed (in sea state 1) of 38 knots and a range of 300NM at cruising speed.

The 18-tonne, 16.3-metre-boat operates equally well in riverine, coastal and open water environments. Its low silhouette, 0.9 metre draft, and manoeuvrability optimise the vessel for settings where it can take advantage of natural cover such as inlets and coastal island chains. Alternately, the vessel's low profile allows it to covertly approach hostile shores across open waters to insert reconnaissance and special operations teams or conduct direct action attack missions from the sea. The reinforced hull permits the boat to run up onto unprepared beaches without damage, or approach rocky, elevated shores where marines and commandos can quickly egress via the bow ramp.


Photo: SAAB/ Jamie Hunter

Saab's Combat Boat 90 Next Generation.

The offensive mission profile focuses on high-speed surprise attacks against enemy forces, either through rapid insertion of commando teams or by deploying as a gunboat. In addition to the three-person crew, passenger capacity consists of 18 fully equipped marines who travel in the climate-controlled and over-pressurised cabin, which provides passengers and crew with ballistic and CBRN protection. For a boat of its size, the CB90 is heavily armed. Weapon options include up to three large calibre machine guns and one MK 19 grenade launcher, as well as naval mines and depth charges. The NG adds the proprietary Saab TRACKFIRE remote weapon sta-

Photo: SAAB/ Magnus Kallin

Trial shooting with TRACKFIRE RWS on Saab's CB90 in a Swedish archipelago, autumn 2019.

tion (RWS) that facilitates precision firing while the boat travels and manoeuvres at high speed.

The CB90NG also features new sensors which enhance its Intelligence/ Surveillance/Reconnaissance (ISR) capabilities. The new combat management system includes a fire control computer and a video tracking system linked to the sensors. The sensor module includes a CCD TV camera, Infrared cameras, and a laser rangefinder/ target designator. The sensor module and laser targeting system are decoupled from the weapons modules and independently stabilised, freeing the sensors from the effect of weapon recoil and providing more consistent fire solutions.

WATERCAT M18 AMC

Finland's Marine Alutech Oy Ab produces a complete line of high-speed vessels suitable for all climes, from the Arctic to the tropics, and for all operational environments from open ocean to littorals, offshore, and inland waterways. Marine Alutech's WATERCAT family of vessels for defence and special operations applications range from small patrol craft to highly survivable troop and assault carriers with a capacity of up to 30 operators. The aluminium and composite hulls are modular in design; mission systems and optional armour packages can be adapted to user requirements.

One of the largest – and newest – vessels in the WATERCAT family is the 20-metre M18 Armoured Modular Craft (AMC), which entered production in 2013. The Finnish Navy acquired 12 units for use as combat support vessels, designating it the JEHU class. These high-speed multipurpose landing craft can be deployed for medical evacuation, general troop transport, assault landing transport, patrol, escort, and combat support missions. Their range is 200 NM. Depending on the mission, the boat crew ranges from 2-5, with up to 26 combat equipped passengers. The boats are equipped with dual-weapon TRACKFIRE RWS, as well as two additional mounts for manually controlled machine guns. The climate-controlled cabin provides crew and passengers with CBRN and ballistic protection. Two Scania DI 16 007 diesel engines (900 hp each) and two Rolls Royce 40A3 water jets enable a cruising speed of 35 knots with a sprint capability in excess of 40 knots. These highly manoeuvrable boats have a 1.1-metre draft and are optimised for offshore, littoral and archipelago environs. The sensor suite includes cameras, forward looking sonar, radar and a depth sounder.

SKJOLD

While technically not assault boats, the Norwegian SKJOLD ("Shield") class coastal defence corvettes deserve mention given their superb speed and manoeuvrability. These 274-tonne vessels achieve sprint speeds over 60 knots. At 40 knots cruise speed they achieve 800 NM operating range.

Their greater size permits the corvettes to wield a significantly greater combat power than standard assault boats. The ship's arsenal includes a 76-mm Otobreda SUPER RAPID deck gun, eight Kongsberg Naval Strike Missile (NSM) anti-ship weapons with circa 100 NM range, MISTRAL air defence missiles, and two machine guns. In contrast to most warships, the SKJOLD class carries its NSM internally in order to preserve the exceptionally low radar profile.

The SKJOLD class' stealth characteristics result from the low-profile, angular design of the hull and from the radar absorbent materials coating the hull. The corvettes are very difficult to detect, especially when operating under cover of Norway's coastal archipelagos. Utilising their own sensors and tied to Norway's coastal surveillance network, the ships can sortie at top speed to intercept approaching vessels. The NSM, in particular, permits them to engage large surface combatants and amphibious warships with deadly precision.

The first of the six SKJOLD class corvettes was commissioned in the Norwegian Navy in 1999, at which time they were considered the fastest military vessels. The class

Photo: Marine Alutech

The Finnish Navy began procuring the WATERCAT M18 in 2014, designating it the JEHU class.

Photo: Finnish Navy

A JEHU assault boat inserts soldiers on a rocky beach.

is currently undergoing a service life extension programme conducted jointly by Kongsberg (which is providing upgraded sensors and combat systems) and UMOE Mandal, the original manufacturer. This programme is expected to extend the coastal defence corvettes' service life beyond 2030.

Interceptors
WP-18

Some interceptors are modelled after racing boats. A prime example is the WP-18, developed by Abu Dhabi-based MAR. The 18.6-metre-long, 13 tonne boat reaches a top speed of 65 knots with a 47 knot cruising speed resulting in a 400 NM operational radius. Operated by the UAE's naval special forces, the WP-18 is primarily deployed to intercept suspicious vessels. The interceptor's three-person crew is seated in a closed cockpit. Most mission systems are automated or remote controlled. This includes the extendable Electro-Optical/Infra-Red (EO/IR) sensor mast recessed behind the cockpit. Weapons options include a retractable 30 mm cannon mounted behind the cockpit, as well as small calibre surface-to-air or surface-to-surface missiles in the bow. Non-lethal defensive systems include the Rheinmetall ROSY Rapid Obscuring System. In addition to counter-terrorist, coastal security and force protection missions, the interceptor is capable of mine-countermeasure and anti-submarine operations in shallow waters.

Photo: Norwegian MoD

A SKJOLD coastal defence corvette.

BARRACUDA XSV-17

The BARRACUDA XSV-17, developed by Irish firm Safehaven is another arrowhead-shaped interceptor. The low-slung 17-metre-long hull incorporates stealth technologies and design, ensuring a very small optical and radar profile. Propulsion is provided by two Caterpillar C12.9 diesel engines (1,000 hp each); top speed and range are 60 knots and 700 NM, respectively. The deep vee, wave-piercing hull remains fully operational at sea state 6, and is able to operate at high speed in sea state 4. Shock mitigating seats are provided for 10 crew and passengers in the climate-controlled main cabin, with room for an additional six in the forward cabin, allowing 16 personnel to travel under cover.

While conceived primarily as a pursuit vessel to protect port, coastal and offshore installations, the XSV-17 can also perform covert surveillance and special operations insertion missions. Remote controlled weapons – either a machine gun or a 40 mm grenade launcher – are carried inside the forward deck to preserve the low radar profile and to mitigate environmental damage. Non-lethal options include the HYPERSPIKE 18 sonic weapon and the ROSY obscurant system.

WATERCAT K13 FIC

The fastest member of Marine Alutech's WATERCAT family is the K13 FIC (fast interceptor craft), with a sprint speed of over 55 knots (cruise speed: 35 knots). The 13.8-metre hull can accommodate a crew of four, plus two passengers. The carbon-reinforced composite hull and wheelhouse offer ballistic protection. Equipment options include a selection of surveillance sensors and light weapons. However, the craft is primarily intended for patrol, surveillance and escort tasks, including prevention of seaborne terrorism, sabotage and smuggling. The Royal Oman Police acquired 14 units in 2017.

FEARLESS SUPER INTERCEPTOR

Louisiana-based Metal Shark produces six different series of boats optimised for military or law enforcement use, with

Photo: Norwegian MoD

Four of the Norwegian Navy's six SKJOLD corvettes.

Photo: Privinvest

WP18 interceptors of the UAE Navy.

Photo: Safehaven

Bridge and passenger section of the BARRACUDA XSV-17.

Photo: Safehaven

The BARRACUDA XSV-17 in rough seas.

over 1,000 vessels in service worldwide. The top end is formed by the offshore-capable FEARLESS SUPER INTERCEPTOR family able to achieve top speeds up to 70 knots, and cruise speeds around 50 knots. This high-performance capability is the result of the "stepped-vee ventilated tunnel" (SVVT) running surface and the powerful propulsion system consisting of two diesel engines with a combined rating of up to 5,000 hp. Hulls can be customised to user specifications, including various open or enclosed configurations and optional ballistic protection, as well as mission-optimised weapon mounts, sensors and additional payload options.

The aluminium-alloy hulled boats come in three sizes, from 13.8 metres to 19.4 metres in length. Size primarily influences mission endurance, payload and passenger capacity. The largest iteration has a 15+ hour endurance at 50 knots and features protected seating for 10.

Patrol Vessels C-MES 40 / C-MES 60

The C-MES 40 (COMMANDER 40) patrol boats designed by Offshore Nautica and

Photo: Marine Alutech

The Royal Oman Police operate 14 WATERCAT K13 FIC vessels, shown here during testing in 2016 in Finland.

Photo: Metal Shark

Artist's impression of the 19-metre (63-foot) variant of the FEARLESS SUPER INTERCEPTOR.

Photo: Offshore CN

Sea trials of the COMMANDER 40 high-speed patrol boat.

built by Italy's MES reach a top speed of 75 knots with minimal load and 65 knots with a full load (four crew, plus 10 passengers). The cruise speed is an impressive 60 knots, thanks to two 820 hp SEATEK diesel engines. The 12.5-metre hull and enclosed crew cabin feature Kevlar ballistic protection against small arms fire. The standard armament consists of one mounted machine gun, which can be augmented by torpedoes or short-range air defence missiles. MES also offers an 18-metre version designated the C-MES 60, which achieves a top speed of 56 knots.

Gibraltar

The British Royal Navy (RN) commissioned its two CUTLASS class fast patrol boats in 2022. Developed by the Marine Specialised Technology Group (MST) in partnership with BMT, these highly agile boats are based on the HPB-1900 variant of a series of HPB designs. The boats are assigned to the Gibraltar squadron. They will conduct coastal security operations and protect warships and other high value vessels visiting Gibraltar. The integrated CGI OpenSea360 bridge system and enhanced situational awareness suite (including electro-optical systems and radar) enhance surveillance and early threat detection capabilities. The hull design, combined with HUMPHREE stabilisation fins, provides excellent seakeeping even under challenging sea states. The propulsion system consists of three Volvo D13 engines (1,000 hp each) and three MJP 350X waterjets, enabling top speeds of 41 knots. An additional six personnel can augment the 19-metre-long boat's crew of six for boarding and security operations. Bow and stern mounts accommodate three machine guns up to .50 calibre, although the RN plans to install smaller calibre guns.

Composite structures and components of the CUTLASS class boats were supplied by Norco. MST is partnering that firm and with BMT again on a new contract awarded in 2021 to supply 18 high-speed patrol craft for the UK Ministry of Defence Police and Gibraltar Defence Police. Their primary mission will be security for UK naval bases at home and overseas, as well as "high-profile" armed patrols of UK coastal waters. The 15-metre-boats are based on the new HPB-1500 design. The high-endurance craft will have a top speed of 30 knots, and carry seven people, including a three-person crew.

Photo: Royal Navy/Crown Copyright

HMS CUTLASS arrives at Gibraltar naval base, November 2021.

Photo: Swiftships

Artist concept of the 45-metre Fast Patrol Boat.

FPB45

Virginia-based Swiftships produces two patrol boats with speeds of 40+ knots. They are configured to operate in all geographic and climate zones worldwide, and are in service with several Middle Eastern naval forces and in the Americas. They are optimised for coastal defence, direct action and interdiction operations including counter-terrorist and counter-piracy missions.

The 45-metre Fast Patrol Boat (FPB45) has an all-steel hull and an aluminium superstructure. It achieves 40 knots with a full combat load, or higher speeds with a partial load. The FPB45 is designed and equipped to defeat enemy fast attack craft and fast inshore attack craft. The armament consists of: one Aselsan 25 mm SMASH remote-controlled stabilised naval gun system mounted on the foredeck; a second 25 mm gun or alternately HELLFIRE or GRIFFIN surface-to-surface missiles mounted on the superstructure behind the bridge; and six machine gun mounts. With a crew of 37 and a 1,500 NM range, the FPB45 is optimised for patrols and direct action missions in hostile environments.

The 35-metre Fast Patrol Vessel (FPV) contains seven watertight bulkheads dividing the boat into eight watertight compartments, significantly enhancing survivability in case of a hull breach. The FPV remains fully operational at sea state 4, and can survive sea state 6. The boat reaches 40 knots with a normal load, and has a 3,000 NM operating range at 12 knots. The boat accommodates a crew of 12 plus additional special operations forces as passengers; four full berthing slots serve the crew ("hot bunking") with an additional 12 reclining seats. The boat is heavily armed with one Raytheon GRIFFIN missile system with two quad launchers, one Aselsan SMASH gun system, and two tripod mounts for .50 calibre machine guns.

Trending Factors

As the above examples show, the borders between assault craft, interceptors and patrol boats can be fluid. Flexibility and multi-mission capability are increasingly in demand. This is partially a reflection of tight budgets, which force naval, coast guard and security forces to maximise the utility of every unit acquired. It also reflects developments in the operational environment of many regions. A service tasked with interdicting arms or drug trafficking today might have to intercept armed military craft tomorrow or ferry commandos to a foreign shore the week after. Navies will naturally prefer vessels that can perform all of these missions with little or no reconfiguration. Size matters too. Larger high speed vessels have greater at-sea endurance and range, can transport more soldiers, and carry a more powerful weapons load, enhancing overall combat power as well as survivability. For all of these reasons, the trend toward larger and multi-mission capable high-speed vessels is bound to dominate the future market .

Unmanned Surface Vessels: Enhancing the Battle Force

Sidney E. Dean

Considerable progress has been made in recent years regarding development of autonomous and semi-autonomous surface vessels.

To date, RHIB-sized armed and unarmed unmanned surface vessels (USVs) have been deployed on force protection, infrastructure security, and general patrol missions, as well as in the mine countermeasures role. Focus is now shifting to the introduction of much larger USVs which can be fully integrated into the battle force to significantly enhance fleet combat capabilities.

USN Integration Plans

Globally, the United States Navy (USN) is at the forefront of this development. The service is interested in procuring both Large Unmanned Surface Vessels (LUSV) and Medium Unmanned Surface Vessels (MUSV); additionally, the USN is planning to field Extra-Large Unmanned Underwater Vehicles or XLUUVs (which are beyond the purview of this article.)
According to the USN's calculations, Large Unmanned Surface Vessels would range from approximately 60-90 metres length and 1,000-2,000 tons displacement, and be equated in size to corvettes. MUSV would be circa 14-60 metres long with up to 500 tons displacement, approximating patrol boats in size.

Credit: Austal

Artist concept of a Large USV with deck-integrated VLS cells, considerable reconfigurable deck space, and a tethered UAV for enhanced situational awareness.

Integrating major unmanned systems across the fleet is considered a vital element of the future force structure. In July 2022, Admiral Mike Gilday, Chief of Naval Operations (CNO), presented his newest Navigation Plan or NAVPLAN. These documents provide insight into the USN's force structure and capabilities planning. The CNO has long argued that the current fleet is too small to meet commitments and carry out the warfighting strategy. NAVPLAN 2022 states the goal of increasing the US Navy's Battle Force (which includes surface combatants as well as combat logistics and support vessels) from circa 300 units today to 523 units by Fiscal Year (FY) 2045. This is to be accomplished largely by introducing 150 large unmanned surface and underwater vessels into the Battle Force over the next two decades. The stated figure would closely approximate a June 2021 Biden administration document suggesting a future force including up to 89 LUSV and MUSV, plus up to 51 large unmanned underwater vessels. Likewise, the Navy's proposals for a 30 year shipbuilding plan, released in April 2022, provide alternate procurement scenarios which range from 27 to 153 LUSV/MUSV units by FY 2052.

Credit: US Navy

Test firing an SM-6 air-and-missile defence missile from the LUSV prototype RANGER in 2021.

Testing and Concept Development

On 13 May 2022 the US Pacific Fleet established Unmanned Surface Vessel Division One (USVDIV One) at San Diego. The unit will manage the USN's LUSV and MUSV experimentation and serve as a bridge between the Navy Sea Systems Command (NAVSEA) UV programme office, and the fleet commanders who will be testing the vessels and providing feedback. USVDIV One has inherited the results of five years worth of extensive testing and evaluation of LUSV and MUSV technology demonstrator seaframes, command and control systems, autonomy systems, and payload integration conducted by various USN and Department of Defense (DoD) research offices through 2021. The squadron currently has two LUSV and two MUSV seaframes, and is expected to acquire three additional units.

A major focus of the unit is systematically integrating the technology demonstrators into regularly scheduled major exercises, testing their capability to integrate with manned warships for high end fleet operations. In addition to testing technology maturation, optimal payload configurations, and command and control systems, the squadron is also using the results of these exercises to develop LUSV/MUSV concepts of operation (CONOPS). Land-based testing of key technologies is running parallel to the at-sea evaluations. According to the USN, platform development and subsystem technical maturation is following a systems engineering framework approach across six lines of effort: reliable hull, mechanical and electrical (HM&E) systems; automated communications systems; integrated combat system; common control system; sensory perception and autonomy; platform and payload prototyping.

The most recent (and to date most significant) USV integration took place during the 2022 Rim of the Pacific (RIMPAC) exercise conducted from 29 June to 4 August near Hawaii and California. It was the first time all four of USVDIV One's vessels participated simultaneously, with each USV being paired with a manned destroyer. "We are fully integrated with the entire RIMPAC exercise, both from a planning standpoint [and] the underway portion – we are fully integrated with the entire command and control network for all of the manned ships here for RIMPAC," said Commander Jeremiah Daley, head of USVDIV One. This included operating the USVs with multinational squadrons and detachments led by allied and partner officers.

Major Mission Types and Payloads

LUSV and MUSV seaframes will be based on robust commercial vessel specifications, and equipped with existing military

Photo: US Navy

A containerised missile quad-pack on the LUSV prototype RANGER. The modular four-cell launcher is presumed to accommodate a variety of missiles including the TOMAHAWK land attack cruise missile.

Photo: US Navy

The large unmanned surface vessel NOMAD transits the Pacific Ocean from California to Hawaii to participate in Exercise RIMPAC 2022.

Photo: US Navy

LUSVs are required to have a large, reconfigurable mission bay to enable flexible payload options.

Photo: US Navy

The LUSV prototype RANGER moored at Pearl Harbor for RIMPAC 2022.

Photo: DARPA

The SEA HUNTER MUSV began as a DARPA research programme to develop an Anti-Submarine Warfare (ASW) reconnaissance vessel.

Photo: DARPA

The SEA HUNTER MUSV with the tethered TALONS sensor.

payloads. The payloads will be modular and can be reconfigured to satisfy changing mission objectives and operational environments.

Current planning calls for equipping MUSVs with sensors and communications links, using them primarily as Intelligence/Surveillance/Reconnaissance (ISR) assets; this includes deploying towed sonar arrays for submarine detection. MUSVs are also likely to be equipped for Electronic Warfare/Information Operations (EW/IO). Exercises to date have, among other things, used forward-located MUSVs to relay targeting data for long-range weapons fired by manned destroyers. One major advantage of this solution is the ability to deceive hostile forces regarding the size and location of US forces, since it will permit the manned warship to operate with passive sensors while relying on the MUSV for the larger situational picture.

LUSVs are to be armed with a variety of kinetic weapon systems, in addition to a sensor suite. They are expected to be fitted with 16 or 32 Vertical Launch System (VLS) tubes to carry Anti-Ship Missiles(ASM) and land attack missiles. Rocket-assisted ASROC anti-submarine torpedos and other torpedo systems are also under consideration. The vessels will be capable of semiautonomous operations, with a human operator standing by on a manned ship or on shore. Weapons payloads can only by released by the remote operators. The vessel's AI will not be capable of autonomously engaging targets. Neither will the LUSV carry components that would enable payload engagement from onboard the vessel; this will prevent unauthorised or hostile forces who board the vessel from gaining operational control of the payload.

Operational Contribution of Large/Medium USVs

The LUSV and the MUSV will both be able to autonomously transit the open ocean and stay at sea for weeks at a time (whereby small crews will have to board the vessels for refuelling). Prototypes of both categories have demonstrated the capacity for autonomous navigation over thousands of miles, while complying with the international collision regulations or "rules of the road."

While they will be capable of operating alone, the current CONOPS planning calls for assigning the unmanned vessels to aircraft carrier groups, amphibious warfare groups, and other surface action units, as well as pairing them with individually deployed manned warships. The

Photo: US Navy

Stern view of the SEA HUNTER MUSV prototype at Pearl Harbor for RIMPAC 2022.

goal is to have several USV support an individual manned ship. This will most likely include both armed and ISR-equipped USVs teaming with the manned ship to provide a full-spectrum support chain. Other scenarios foresee teaming several USV and several manned vessels into a mixed detachment for larger scale missions. Teaming does not require the manned and unmanned vessels to sail in close proximity. Rather, the USVs' utility will be maximised by dispersing the units to cover a broad area. Unmanned units will relay their situational data to controllers on the manned vessel, who will in turn redirect the USVs or order engagement of weapons or particular assets, as the situation dictates.

In this way, LUSVs and MUSVs will support the US sea services' Distributed Maritime Operations (DMO) concept of wartime operations. Dispersing combat-capable ships is credited with two advantages: permitting coordinated attacks to be carried out from a greater number of locations and directions, straining enemy defences; and making it more difficult for the enemy to locate and target a major percentage of US fleet assets. In addition to supporting the Distributed Maritime Operations concept, simply introducing a large number of LUSV will also significantly increase the available weapons payload with a comparatively modest financial investment, and with minimal demand for personnel.

Both USV types will be able to support, among other specific mission concepts, the Expeditionary Advanced Base Operations (EABO). This joint Navy/US Marine Corps concept calls for small, mobile USMC units to conduct swift mobile operations along the western Pacific island chains in case of war with China. LUSV (and MUSV) could support such missions by performing ISR operations across a wide area, providing direct fire support for landing operations, and independently striking enemy warships as well as high-priority military targets (air defence, missile launching sites, airfields) on the islands in question.

Photo: L3 Harris

L3 Harris has a contract to develop at least one MUSV prototype, with options for another eight.

Taking the various contributions into account, the USN maintains that fielding significant numbers of large, armed USVs will support development of a more distributed and lethal force.

European Interest

There has also been European interest in high-performance USVs, although the majority of systems being tested or fielded are smaller, with only a few days endurance at most. Yet the operational value of larger systems has been clearly recognized. In that light, the European Defence Agency (EDA) in November 2021 launched the Medium-Size Semi-Autonomous Surface Vehicle (M-SASV) project which is being jointly implemented by Estonia, France, Latvia and Romania, with Estonia acting as project coordinator. The goal is a USV in the 250-500 ton range, capable of mounting multiple mission modules for ISR, Anti-Submarine Warfare, Surface Warfare, and Mine Warfare/Mine Countermeasures. The primary focus is on littoral operations, but the vessel will be capable of integration into naval task groups deployed on the high seas. The M-SASV can optionally field a small crew when mission circumstances require it.

Moving Forward

The US Navy's FY 2023 budget request includes USD 549 million for continuing LUSV/MUSV research and development. The five-year 2023-2027 shipbuilding plan calls for LUSV procurement to begin in FY 2025 with one ship, followed by two units in 2026 and an additional three in 2027. Unit costs are expected to drop from USD 315 million for the first unit to circa USD 241 million for each ship procured in 2027. Admiral Gilday stated in February 2022 that he would like to begin integrating LUSVs into carrier strike groups and amphibious readiness groups no later than 2028, and gradually increase the number of these vessels in the fleet in the 2030s.

USN commitment to MUSVs is less certain. The 2023-2027 shipbuilding plan does not provide for any MUSV procurement during the stated timeframe. In April 2022 Admiral Gilday said that the service was rethinking acquiring MUSVs after experiments demonstrated that small USVs carried aboard manned warships were able to make a significant contribution to ISR missions and establishment of a common operational picture. "I don't know whether we will have a medium [USV] or not," Gilday said. "I'm not saying that we don't need an MUSV. I'm saying it will cause us to consider [numbers of such platforms that may be needed.]" The CNO implied that decisions whether or not to procure MUSVs may not be taken until circa 2030.

Credit : US Navy

The SEA HUNTER MUSV prototype at Pearl Harbor for RIMPAC 2022.

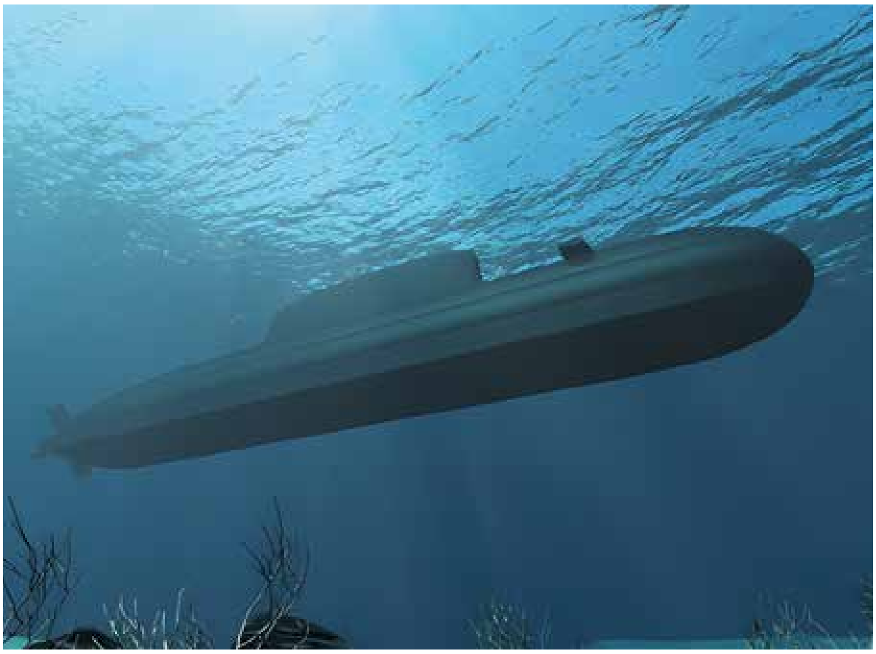
Conventional Submarine Builders

Bob Nugent

This article examines the current state of the conventional submarine industry world-wide, drawing on data provided by US-based market intelligence specialist AMI International. It begins with a survey of the current conventional submarine fleet and their construction facilities. Next is a review of the next two decades of projected submarine acquisitions, focussing on programmes and facilities that are building submarines now. It closes with some highlights of recent advances in construction techniques and new conventional submarine designs.

The global market for submarines remains robust, as conflicts and maritime security challenges grow in many regions, driving demand for the strategic advantages submarines provide navies large and small. While nuclear-powered hulls represent the top end of the submarine market, their specialised technical requirements, and the expense of building and operating them, continues to limit "nukes" to a few nations. The conventionally powered submarine is the favoured choice for most of the world's navies, and the builders of these types of submarines are not only building more hulls to meet growing demand, but also integrating advances in manufacturing techniques, propulsion, weapons (missiles), sensors and command and control systems into their submarine offerings.

Image: tkMS



Artist impression of the Israeli DAKAR class submarine.

AMI identifies 537 submarines and submersible vehicles in active service as of August 2022. Of those, 382 (just over 70%) are conventionally-powered submarines built since 1945. Filtering that count down to submarines displacing 1,000 tonnes or more and built since 1982, AMI identifies 249 hulls. Those hulls and building country of origin are identified in the chart below:

Country	Hulls	Yards/ Facilities
Russia	54	5
China	47	3
Germany	36	1
Japan	24	2
ROK	26	2
Italy	9	1
Turkey	8	1
Australia	6	1
Sweden	6	1
India	6	1
Netherlands	6	2
France	5	1
UK	4	1
Iran	3	1
Greece	3	1
Brazil	2	2
Spain	2	1
North Korea	1	1
Indonesia	1	1
Total	249	

Among countries with conventional submarine building yards now in operation, Russia and China continue to support the largest infrastructure, delivering for domestic service as well as export customers. In Europe, Germany continues to be the region's foremost conventional submarine builder, with most of those hulls built for export. Italy, France, Spain, Sweden and Turkey also have submarine building capabilities that support both domestic and export requirements. In the Asia-Pacific region, Japan, the Republic of Korea, and India are the region's leading

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builders, with Indonesia developing capacity through a combined programme with Korean industry. Australia has some residual submarine construction capacity, although the ASC yard that built the COLLINS class (based on a Swedish Kockums design), delivered the last hull of that class in 2003. In South America Brazil is the only nation with a local submarine construction capability, based on their current programme teamed with French company Naval Group.

Future Market

AMI forecasts that 161 new conventionally powered submarines will be built and join global navies over the next 20 years, with an estimated acquisition expenditure of over US$100Bn. Thirty one countries are identified as having conventional submarine programmes either planned or building now. Nineteen countries are acquiring new hulls now, representing 65% of the future market measured by acquisition costs and 60% of the future market measured by hulls, respectively.
These current submarines programmes, summarised below, will be the focus of the remainder of this article, as they represent current and proven conventional submarine builders at work today.

Discussion

It is noteworthy that among the 21 programmes listed above, only 2 (Japan and South Korea) are pursuing a "split build" with workshare divided up among two shipyards. While more expensive, this acquisition strategy mitigates programme risk by having alternative paths should one of the yards involved encounter delays or difficulties. Another merit of this approach is having additional infrastructure to support future repairs and modifications. The United States uses this acquisition strategy for construction of nuclear-powered attack submarines.
Another point that emerges from this table in the increasing tendency for countries to build up construction expertise via local workshare in their submarine acquisition programmes. Submarine building is a high-tech and expensive activity, and it is

Country	Programme	Builder
Brazil	» RIACHUELO (SCORPÈNE) Class Diesel Electric Submarine (SSK)	Hull 1: Naval Group shipyard in Cherbourg, France; Brazil-Itagua Construções Navais (ICN) yard; Hulls 2-4 Brazil Sepetiba Bay that opened in late 2013
China	» YUAN (Type 041) Class Attack Submarine (SS)	Wuhan Shipyard, Hubei, China
Germany	» Type 212CD Class Submarine	ThyssenKrupp Marine Systems (TKMS)
India	» KALVARI Class Diesel Electric Submarine (Project 75)	Mazagon Dock Ltd. (MDL), Mumbai with assistance from Naval Group
Indonesia	» NAGAPASA Class Submarine	Hull 1: Korea DSME Hulls 2-10: DSME + Indonesia PAL
Iran	» FATEH Class Diesel Electric Submarine (SS)	Persian Gulf Shipbuilding Co. (PGSC) in Bandar Abbas and Bandar Anzali.
Israel	» DOLPHIN II Class Submarine	TKMS
Israel	» DAKAR Class Submarine	TKMS
Italy	» Near Future Submarine (NFS) Type 212 (Todaro Batch III)	Fincantieri Muggiano
Japan	» TAIGEI Class Diesel Electric Submarine (SS) (formerly 3000-Ton Submarine)	3 hulls: Kawasaki Kobe Yard (three units) 3 hulls: Mitsubishi Heavy Industries Ltd Kobe Yard
Norway	» Type 212CD Submarine	TKMS HDW (possibly some modules in Norway)
Pakistan	» HANGOR (YUAN Type 041) Class Submarine (SSK)	Wuhan and Jiangnan Shipyards in China and Karachi Shipyard and Engineering Works (KSEW), Pakistan.
Russia	» SAINT PETERSBURG (Project 677) Class Conventionally Powered Attack Submarine (SSK)	Admiralty Shipyards in St. Petersburg.
Russia	» Improved KILO Class (Project 636.3) Conventionally Powered Attack Submarine (SSK)	Admiralty Shipyards in St. Petersburg
Singapore	» INVINCIBLE (Type 218SG) Class Diesel Electric/AIP Submarine	TKMS
South_Korea	» DOSAN AHN CHANGO (KSS-3) Class Submarine (Batch I + II + III)	Units 1 & 2: DSME Unit 3: Hyundai Heavy Industries (HHI). Unit 4: DSME Units 5 - 9: DSME and HHI.
Spain	» ISAAC PERAL (S 80A) Class Diesel Electric Submarine	Navantia Cartagena Yard
Sweden	» BLEKINGE (A26) Class Submarine (5)	Saab Kockums
Taiwan	» INDIGENOUS Defensive Submarine (IDS)	SBC Corporation - Taiwan with foreign assistance
Thailand	» MATCHANU (S26T) Class Submarine (SS)	Wuchang Shipyard in Wuhan China.
Turkey	» REIS (Type 214) Class Diesel Electric Submarine	Golcuk Naval Shipyard from TKMS HDW kits.

not surprising that countries are seeking more return on investment in such programmes by developing local capabilities through technology and expertise transfer from foreign designers and builders. Both South Korea and Turkey are examples of countries the submarine programmes of which began heavily dependent on foreign partners, but advanced to gain an independent construction capability.

Advances in Conventional Submarine Construction Techniques and Designs

Composite materials use in submarine construction dates back decades, in the case of fibre-reinforced plastics in the HDW Class 206A submarines, first put into service in the late 60's. The weight savings, flexibility and other production

damaged metal surfaces on the RAN's COLLINS' class submarines. Specifically, the project will explore the potential of cold spray technologies for local repairs. As ASC is the shipyard most likely to lead local involvement in Australia's future submarine program, results from this project are expected to be incorporated in future submarine component construction at the facility.

Photo: Naval Group

Naval Group's SMX-31E Concept Submarine.

Programmes in Indonesia, Pakistan, India, Taiwan and Brazil are following this technology and construction sharing approach, while Norway, Singapore, Israel and Thailand are pursuing a more historically traditional outright purchases from foreign builders.
China's growing role in the export market for conventional submarines stands out. Programmes in Pakistan and Thailand are China's initial submarine export customers, and the country's shipyards are expected to seek to build on the momentum from these programmes to compete for future awards expected in the coming years. Submarine programmes AMI projects for contract award in the next five year where China is positioned to compete include Myanmar and several countries in South America.
Summarising, the world's conventionally powered submarine industry is concentrated in a few facilities, with the table above identifying fewer than 20 worldwide. These facilities concentrate exceptional design and construction capability in a relatively small number of specially-skilled hands, ranging from naval architects to materials specialists, and the welders and fitters that bring these hulls into being. While the current demand for submarines appears strong enough to maintain this "just enough" infrastructure, the question arises as to whether and how these shipyards are developing the next generation of submarine makers, and how they might respond to a sudden spike in demand for both construction and repair in the event of a larger-scale or sustained conflict in the subsurface maritime domain.

advantages of composites on submarines continue to make them a material of choice, for example being used for parts of the upper superstructure, sail and sonar windows on the Type 209 design. TKMS states glass-fibre-reinforced plastics (GRP) and carbon-fibre-reinforced plastics (CFRP) are used on the Type 212A and Type 214 submarines now in production, citing their use for large 3D shapes or to meet transparency requirements (sonar). Other applications include life raft containers, torpedo countermeasures launching tubes, rudders, shafts and propellers.

Additive Manufacturing

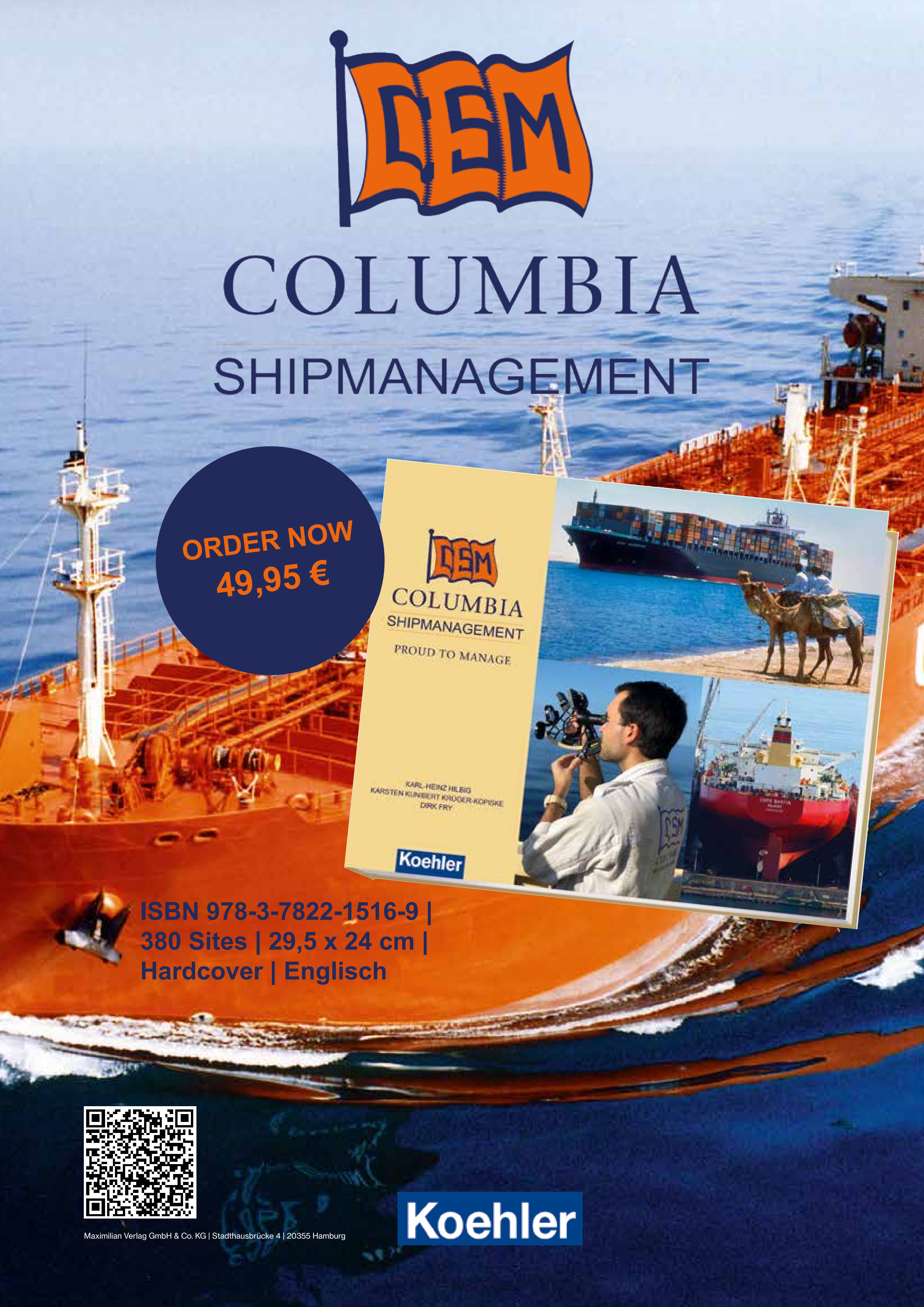
Additive Manufacturing is beginning to be incorporated in submarine component construction, successfully demonstrating the ability to meet higher standards typical in all aspects of submarine building. In 2019 TKMS received classification society approval to introduce "3D printing" to its manufacturing processes. By July 2020 the company announced that standard parts obtained from the 3D printers were being installed on submarines, specifically citing plastic tube bundle holders, and steel housings for ventilation systems.
In February 2021, Australia's submarine sustainment provider ASC, DMTC (ex-Defence Materials Technology Centre) and the country's science agency CSIRO announced a teaming agreement to explore how additive manufacturing technology might be applied to repairing

TKMS: Israeli DAKAR Class

Ordered in January 2022, the three submarines in Israel's DAKAR class are described as a "completely new" design, departing substantially from the specifications of the preceding DOLPHIN class. Changes include a larger overall size (estimated at 2,800 tonnes submerged compared to the 2,200 tonnes of the DOLPHIN II), a larger sail, a vertical missile launch system (potentially in the larger sail, or hull-mounted), a cruciform X tail design, and new Air Independent Propulsion (AIP) systems. The submarines will be built at the shipyard's Kiel facility. If the DAKAR class is 2,800 tonnes (some sources state it will displace 3,000 tonnes), it would represent the largest conventionally powered submarine built by TKMS (formerly HDW).

Naval Group: SMX-31E "Concept" Design

Another large (3,200 tonnes submerged) conventionally powered design is from France's Naval Group, which describes it as integrating digital technologies to operational efficiency and mission flexibility. The company also claims improved quieting for the hull using biomimetic coatings. The design's new propulsion concept includes expanded energy storage capacity, increasing its range and mission duration. Also noteworthy is the smaller crewing requirement – just 15 – leaving room to embark additional mission-specific personnel.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Logistic Support Ship Programmes: Status Report

Conrad Waters

The provision of effective logistical support remains a fundamental requisite for the effective performance of 'blue water' naval operations. Following a slowdown in procurement during the post-Cold War era, navies in both North America and Europe are now undertaking major programmes to recapitalise their inventories of replenishment vessels. The expansion of fleets across the Asia-Pacific region is another significant driver of new investment in the segment. This status report examines some of the major projects that are currently underway.

North America

The United States Navy (USN) currently operates the world's largest force of logistic support ships through the Military Sealift Command. Its principal logistical assets can broadly be divided between the 14 dry cargo and ammunition ships of the LEWIS AND CLARK (T-AKE-1) class and the 15 fleet oilers of the HENRY J. KAISER (T-AO-187) series[1]. The latter trace their origins to the later years of the Cold War. The majority do not comply with modern environmental standards, lacking double hulls. Accordingly, a major programme to replace and expand the navy's flotilla of oilers is currently underway.

The replacement programme is based on the JOHN LEWIS (T-AO-205) design. Displacing around 50,000 tonnes at full load, these ships are reported to have a similar – 157,000 barrel – oil capacity to their immediate predecessors, as well as increased provision for dry cargo[2]. Replenishment facilities include five refuelling stations and two transfer rigs for dry cargo, the latter being supported by two, five-tonne cranes. All ships are double-hulled. Propulsion is by means of a twin shaft diesel arrangement. This provides a maximum speed in the region of 20 knots and an endurance at economical speeds in excess of 6,000 nautical miles.

A contract for the first six members of the class was signed with the General Dynamics NASSCO shipyard in San Diego in June 2016. The lead ship was delivered on 26 July 2022. Three additional members of the class were at various stages of construction as of mid-2022 and a total of eight have now been ordered following an additional contract award in Au-

Photos: General Dynamics NASSCO

JOHN LEWIS (T-AO-205) – pictured here running trials early in 2022 – is the lead ship of a new class of 20 fleet oilers destined for the US Navy's Military Sealift Command.


Photo: Crown Copyright 2018

Canada's new PROTECTEUR class joint support ships are based on the German Type 702 BERLIN class design.

gust 2022. Current US Navy plans call for a total class of 20 ships. Current unit cost is in the region of US$730M.

The USN's move towards Distributed Maritime Operations (DMO) is anticipated to expand the requirement for logistic support vessels due to the more arduous nature of sustaining a dispersed fleet. This requirement is expected to be met by acquisition of a new fleet of Next Generation Logistics Ships (NGLS) under a programme initiated in the US Navy's FY2021 budget request. The NGLS project envisages a family of vessels that will be smaller and cheaper than existing replenishment vessels and which are therefore more suitable for exposing to hazard in a contested environment. The precise nature of the design and the number of NGLS to be purchased is not yet entirely clear. However, unit cost is expected to be around US$150M or only around a fifth that of the JOHN LEWIS class. Procurement of the first is expected to be approved in the FY2026 budget.

Elsewhere in North America, the Royal Canadian Navy continues to await delivery of two new PROTECTEUR class joint support ships. These are being built by Seaspan's Vancouver Shipyard under the framework of the country's National Shipbuilding Strategy. The vessels will be variants of the German Thyssenkrupp Marine Systems (TKMS) Type 702 BERLIN combat support ship design under a decision announced in 2013. As such, they are large and sophisticated vessels that are able to supply both liquid and solid cargo. They also benefit from significant operational flexibility through use of a large, modularised container capacity. Fabrication of blocks for the first vessel commenced in 2018 prior to a formal keel-laying ceremony in January 2020. However, it was not until the middle of that year that a contract for the full construction of the pair was formalised. Subsequently, in June 2022, it was announced that planned deliveries of the two ships will be pushed back two years to 2025 and 2027 as a result of "sustained supply chain delays due to the COVID-19 pandemic and further challenges related to a first-of-class delivery". Current estimated programme cost is C$4.1Bn (circa US$3.1Bn). This is a truly eye-watering number that reflects the very high expenditure associated with re-establishing Canada's domestic naval construction capacity.

Italy & France

Turning to Europe, the renewal of both Italy's and France's naval logistical support capacity is being carried out under what is effectively a joint project. This traces its origins to the authorisation of a single auxiliary replenishment oiler (AOR) for the Italian Navy under the wider acquisition programme implemented by the 2014 Naval Law. The logistic support ship's procurement was managed by the European collaborative defence programme management agency OCCAR. This ordered the vessel from a Fincantieri-led consortium in May 2015. Fabrication was shared between the builder's Castellammare di Stabia and Riva Trigoso shipyards, with integration work carried out at Muggiano near La Spezia. A fire during construction and the subsequent impact of the pandemic delayed completion of the project. However, the ship – named VULCANO – was ultimately delivered in March 2021. Displacing a little over 27,000 tonnes at full load, the new ship is able to carry 15,500 tonnes of liquid and solid cargo. Replenishment is by means of two stations to both port and starboard, a stern refuelling position and twin cargo handling cranes. A Combined Diesel-Electric And Diesel (CODLAD) propulsion train provides a cruising range of 7,000 nautical miles and a maximum speed of 20 knots.

The Italian Navy has plans to replace its three 'legacy' replenishment oilers on a one-for-one basis. Accordingly, a contract for a second member of the class was placed with Fincantieri through OCCAR in December 2021. The agreement also contained an option for the required, third ship. In contrast to the previous assembly arrangement, construction will be entirely allocated to the Castellammare di Stabia yard, which commenced fabrication on 20 July 2022. The contract award – including provision of a combat management system – amounts to €410M (US$410M), a price which compares favourably to the other programmes already discussed.


Photo: Fincantieri

Italy's logistic support ship VULCANO has formed the basis of a new fleet of auxiliary replenishment oilers for both the Italian and French Navies.

Photo: Bruno Huriet

France's JACQUES CHEVALLIER, which is based on the VULCANO design, is pictured here at the time of float out from Chantiers de l'Atlantique in April 2022.

Meanwhile, in January 2019, France's defence procurement agency agreed a €1.9Bn contract for four vessels based on the VULCANO design with a consortium comprising the Saint–Nazaire based Chantiers de l'Atlantique and Naval Group. The order is intended to meet the French Navy's need to replace the remaining elderly replenishment oilers of the DURANCE class under its FLOTLOG ("flotte logisitique") programme. The ships will be known as "Bâtiments Ravitailleurs de Forces" (BRF) in French Navy parlance. The selection of the design over a purely national concept was driven by Fincantieri's planned acquisition of a controlling stake in the Chantiers de l'Atlantique shipyard; a transaction that was subsequently abandoned in January 2021 in the face of opposition from the European Union's competition authorities. Nevertheless, the programme represents a good example of ongoing Franco-Italian collaboration in the naval sphere which looks set to be taken further by the Naviris joint venture.

In similar fashion to the VULCANO programme, procurement of the French replenishment vessels is being carried out under OCCAR's supervision. Construction is being split between Castellammare di Stabia and Saint-Nazaire, with consolidation of the constituent sections and final outfitting being carried out at the French yard. Work on the lead ship – JACQUES CHEVALLIER – commenced in May 2020 and she was floated out on 29 April 2022. Sea trials are expected to commence by the end of the year to allow delivery in the first half of 2023. The remaining three vessels will follow before the end of the decade. The French vessels are reportedly somewhat heavier than their Italian counterparts with a full load displacement in the region of 31,000 tonnes. Differences will include specification of a French combat management system and an alternative self-defensive armament.

Photo: Crown Copyright 2021

The British Royal Fleet Auxiliary's TIDE class were built in South Korea at considerably less expense than comparable European-built ships. This picture shows TIDERACE in 2021.

United Kingdom

Unusually in Europe, the British Royal Navy's logistic support flotilla follows US Navy practice in being split between designs focused on bulk (liquid) and non-bulk (general stores and ammunition) replenishment. Another similarity is the ships' operation by the Royal Fleet Auxiliary (RFA); a distinct, civilian-crewed organisation similar in concept to the Military Sealift Command. The liquid replenishment element of the RFA's recapitalisation was concluded between 2017 and 2019 with the entry of the new TIDE class fleet tankers into operational service. Built by DSME in South Korea to the BMT Defence Services AEGIR® 26 concept, these 39,000-tonne ships can carry over 20,000 tonnes of liquids but have a very limited capacity for solid stores. An important aspect of their procurement was a total programme cost of circa £550m (US$650m). This makes the project one of the most cost-effective considered by this article.

Acquisition of a new class of Fleet Solid Support (FSS) ships to transport stores and ammunition has proved far more problematic. A major difficulty has been political indecision with respect to the cost benefits of outsourcing construction to an overseas yard against the backdrop of a National Shipbuilding Strategy that is attempting to revitalise the indigenous naval sector. An international competition for the new ships was suspended late in 2019 after a number of competitors had dropped out on the basis that none of the remaining proposals met the required budget. The programme was subsequently recast with a higher, £1.7Bn (circa US$2Bn) budget for a total of three ships and requirements that mandated a greater level of domestic involvement. Subsequently, in September 2021, Competitive Procurement Phase (CPP) design contracts to help determine a winning proposal were awarded to four consortia, namely:

- Larsen & Toubro, including British company Leidos Innovations.
- Serco /Damen, including British company Serco.

Photo: Damen

The Dutch DEN HELDER is set to become operational in 2025, bolstering the Royal Netherlands Navy's deleted replenishment capability.

- Team Resolute, including British companies Harland & Wolff and BMT.
- Team UK, which including British companies Babcock and BAE Systems.

It is reported that the resultant CPP proposals have now been received and that a final decision will be taken by March 2023. The four consortia encompass varying levels of indigenous involvement. Whilst not all the bidders have disclosed their approach, it would seem that the all-British Team UK and Team Resolute – which is working in partnership with Spain's Navantia – would seem best placed to ensure a material amount of domestic construction. Whichever bidder is successful, it is envisaged that the first FSS ship will be operational by 2028 and all three by 2032. Tender documents suggest that they will be required to carry up to 7,000m³ of stores at sustained speeds of up to 18 knots and to be able to transfer single loads of up to five tonnes whilst on the move.

The Rest of Europe

Amongst other European navies, Germany's programme to replace the elderly, single-hulled Type 704 RHÖN class oilers with a pair of new Type 707 vessels is amongst the more significant. The two oilers were contracted with the then Lürssen – now NVL – in July 2021 following receipt of parliamentary approval the previous month. The €870M contract will be carried out in conjunction with fellow German shipbuilder Meyer Werft. Much of the physical construction work will be allocated to Meyer's Neptun yard at Rostock. Deliveries are expected to commence in 2024. Displacing in excess of 20,000 tonnes, the new vessels will be able to transport 12,000 tonnes of fuel at speeds of up to 18 knots and have a cruising endurance of 8,000 nautical miles. Up to three ships can be replenished simultaneously. Although representing a significant improvement over the previous class, the programme has been criticised for its relatively high cost compared with other, arguably more capable European programmes. The new ships' 9.5 metre draught – supposedly adopted to allow access to a wider range of reference designs – is also greater than the previous vessels. This means that they will have difficulty in accessing the major

Current Logistic Support Ship Programmes

Specimen Logistic Support Ship Data

Class	JOHN LEWIS	PROTECTEUR [2]	VULCANO[3]	TIDESPRING	TYPE 707	AOTEAROA
Country (Design):	USA	Germany	Italy	UK	Germany	UK
Country (Build):	USA	Canada	Italy/France	South Korea	Germany	South Korea
Country (Navy):	USA	Canada	Italy/France	UK	Germany	New Zealand
Number Ordered:	8	2	2/4	4	2	1
First Commissioned:	2022	[2025]	2021/[2023]	2017	[2024]	2020
Role[1]:	AO	AOR	AOR	AO	AO	AOR
Full Load Displacement:	50,000 tonnes	21, 000 tonnes	27,000 tonnes	39,000 tonnes	20,000+ tonnes	26,500 tonnes
Dimensions:	227m x 32m x 10m	174m x 24m x 7m	183m x 24m x 8m	201m x 29m x 10m	170m x 24m x 10m	173m x 25m x 8m
Propulsion:	Diesel	Diesel	CODLAD	Hybrid CODLOD	Hybrid Diesel/ Diesel-Electric	Hybrid CODLAD
Speed:	20 knots sustained	circa 20 knots	circa 20 knots	15 knots sustained	circa 18 knots	16 knots sustained
Endurance:	6,000+ nautical miles	11,000 nautical miles	7,000 nautical miles	8,000 nautical miles	8,000 nautical miles	6,500+ nautical miles

Notes

1. AO = auxiliary oiler (liquid fuel supply); AOR = auxiliary replenishment oiler (liquid fuel & solid stores supply.
2. Based on Type 702 BERLIN class, three of which have been delivered to the German Navy.
3. Data based on the Italian Navy VULCANO class; the French Navy's JACQUES CHEVALLIER class have detailed differences.

Photo: US Navy

New Zealand's POLAR class replenishment vessel AOTEAROA was built in South Korea to a European design.

naval base at Wilhelmshaven without additional dredging.

The Netherlands are also making progress with rebuilding their replenishment capacity after significant cutbacks in the post-Cold War era. The new combat support ship DEN HELDER is currently being fabricated at Damen's Galati shipyard in Romania, from which the first sections were launched in April 2022. Following final outfitting in The Netherlands, she is expected to be operational by 2025. Displacing just under 23,000 tonnes at full load, the new ship will be able to transport around 9,000 tonnes of liquids, as well as solid stores. Estimated programme cost of circa €375M is broadly comparable with that of similar European projects.

Meanwhile, the Turkish Navy's logistic support capabilities will soon receive significant enhancement with completion of the DIMDEG project for a sea replenishment and combat support ship. A contract for the new vessel was placed with local shipyard Sefine in June 2018, with delivery anticipated in the course of 2023. The new ship – named DERYA – is expected to displace around 26,000 tonnes, making her broadly similar in size and capacity to other modern European replenishment oilers. However, a major departure is the specification of twin GE LM2500 series gas turbines as part of a CODAG propulsion train, giving a design speed in excess of 24 knots. The Turkish naval sector has also gained some success exporting replenishment ship designs overseas. The most notable example is the Karachi Shipyard and Engineering Works-built MOAWIN, which was completed to a STM design in October 2018.

Asia-Pacific

Another country that could potentially benefit from Turkish expertise in the logistic support segment is India. Its Hindustan Shipyard has partnered with the Turkish TAIS consortium for technological support for five new fleet replenishment tankers that would provide a significant boost to the Indian Navy's rather limited logistic support capacity. The parameters of the programme have been in place for a number of years. However, conclusion of an agreement has been continuously postponed, possibly because of disquiet over Turkish industry's support for the rival Pakistan Navy referenced above. Limited information available about the new ships suggest that they will be large vessels of around 45,000 tonnes full load displacement. Maximum speed will be in the region of 20 knots.

India's desire to bolster its naval replenishment assets is indicative of a wider trend across the Indo-Pacific that has been driven by broader naval expansion. The most notable example is China's series construction of Type 903 (NATO: 'FUCHI') class replenishment oilers and the larger and more sophisticated Type 901 ('FUYU') combat support ships. The latter type are seemingly optimised to sustain operations by the People's Liberation Army Navy's growing carrier force. Accordingly, various local sources suggest an additional batch is now under construction to join the initial pair delivered between 2017 and 2019. It would also seem possible that China's naval export industry will seek to export variants of the Type 903 design to friendly nations in similar fashion to its successful sale of other warship types.

For the time being, it is the Republic of Korea's shipyards that are the most important regional players in the sector. DSME's successful delivery of the British TIDE class was followed by completion of the Royal Norwegian Navy's logistic support vessel MAUD, which was also derived from the AEGIR series of designs. Reported programme cost amounted to just NOK 1.3Bn (US$140M) in another example of the cost-advantage enjoyed by Far Eastern yards. Rival shipbuilding giant Hyundai Heavy Industries has also gained export success through New Zealand's mid-2016 contract for construction of the innovative Polar-class support ship AOTEAROA. Built to a Rolls-Royce (now Kongsberg) "Environship" concept, the 26,500 tonne vessel can transport 9,500 tonnes of liquid cargo at speeds of up to 20 Knots. She is also "winterised" for Antarctic operation. The programme cost of NZ$495M (US$300M) was somewhat higher than for other South Korean-built vessels. However, this appears justified by the bespoke nature of the Royal New Zealand Navy's requirements. Whilst all these projects were completed to European designs, it is also worth noting that South Korea has completed replenishment ships to its own specifications to meet Republic of Korea Navy requirements. The most recent was the fast combat support ship SOYANG (AOE-51). She is the lead ship of a new AOE-II programme delivered in 2018. Displacing 23,000 tonnes, she can transport a cargo of up to 10,000 tonnes of liquids and additional solid stores at speeds of up to 24 knots. Further units of the class are planned. Looking to the future, it seems likely that the deteriorating geopolitical outlook will only increase naval requirements to sustain prolonged fleet operation. As such, additional requirements for logistic support shipping are likely to emerge.

Notes

1. The US Navy is unusual in dividing most of its logistic support fleet between specialised bulk (i.e. liquid) and non-bulk (food, ammunition and general stores) replenishment shipping, although each type has limited capacity to supply both types of stores. This probably reflects the carrier strike group-focused nature of its fleet. Most other navies tend to operate auxiliary replenishment oiler (AOR) type ships combining liquid and (limited) solid stores capabilities.

2. The US Navy's barrel stowage metric is at odds with the more universal use of tonnes to denote stowage capacity. The JOHN LEWIS class's 157,000 barrel of oil capacity roughly equates to 23,000 tonnes.

Offensive Ambition: Recapitalising the US Navy's Mine Inventory

Richard Scott

For much of the post-Cold War period, the US Navy put offensive mining to the back of its thinking. There was a sense that the mine was a weapon from a different era with limited operational relevance – and the navy's war stock atrophied as a result.

Today, the US Navy's existing mine inventory comprises the QUICKSTRIKE family of shallow-water, air-dropped bottom mines used against surface and subsurface craft, and the Mk 67 Submarine Launched Mobile Mine (SLMM). The latter is designed for deployment from submarines in areas inaccessible for other mine deployment techniques, or for covert mining.

The Mk 62 and Mk 63 QUICKSTRIKE variants utilise a Mark 80-series general purpose bomb with the fuze replaced with a Target Detection Device (TDD), a Safe/Arm (S&A) device in the nose, and a parachute-retarder tail kit in the rear. The Mk 62 is created by adding mine hardware to the Mk 82 500 lb general purpose bomb, while the Mk 63 is a similar adaptation of the Mk 83 1,000 lb bomb. The third QUICKSTRIKE variant, the 2,000 lb Mk 65, is different in that it uses a thin-walled mine case rather than a bomb body.

Photo: US Navy

A Mk 63 QUICKSTRIKE mine pictured mounted on a P-3 ORION maritime patrol aircraft. The QUICKSTRIKE family of shallow-water, air-dropped bottom mines form the major part of the US Navy's existing mine inventory.

QUICKSTRIKE

QUICKSTRIKE Mod 3, which represents the most recent kit instantiation, utilises a newly developed software programmable TDD Mk 71 which can be programmed to optimise detection of specific threats. For the Mk 62 and 63 mines, the QUICKSTRIKE Mod 3 Kit consists of the TDD (including the service and dummy Mk 71), S&A devices (including the service Mk 75, practice Mk 81 and dummy Mk 84), battery (Mk 176), TDD adapter ring Mk 163, and miscellaneous hardware. As regards the Mk 65 variant, the Mod 3 Kit comprises the TDD (including the service and dummy Mk 71), the existing S&A devices (including the service Mk 45 and practice and dummy S&A devices), the existing batteries Mk 131 or 132, TDD adapter Mk 157, and miscellaneous hardware.

The key drawback of the legacy QUICKSTRIKE mine family is that it requires the carrier aircraft to fly directly over each planned minefield at low altitude and speed to deliver mines. This leaves the aircraft highly vulnerable to adversary anti-aircraft weapons.

The Mk 67 SLMM, which is based on the old Mk 37 heavyweight torpedo, was first introduced in 1983. Depth-rated to 600 feet, and packing a 150 kg high explosive payload, the Mk 67 uses a combination magnetic/seismic/pressure TDD. Although still being out-loaded to submarines as 'expeditionary ordnance' – recent US Navy photo releases have showed the embarkation of Mk 67 weapons to boats operational with the 6th Fleet in the Mediterranean and the 7th Fleet in the Indo-Pacific – the SLMM is now regarded as obsolescent.

Renewed Interest

Now, however, as US naval planners decide how best to meet the growing challenge from peer and near-peer adversaries, there is renewed interest in the sea mine as a means to constrain or deny freedom of movement to adversary shipping in any future conflict. Accordingly, with an increasing emphasis on major regional conflicts and a return to 'Great Power competition – particularly in the Indo-Pacific – moves are now being made to attach a higher priority to offensive mining in the US Navy.

This is reflected in plans to recapitalise the navy's mine inventory through both modernisation and new development. Having invested little in offensive mining for decades, the USN is now committing resources across a number of project areas: development of mines for deployment from aerial platforms and undersea un-

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manned systems to enable safe stand-off delivery; adding command and control of deployed minefields; improving target detection against modern threat vessels; and updating minefield planning tools to meet operational timelines.

Historical Context

"The effectiveness of the mine has not decreased with the coming of the space age," wrote Ralph D Bennet, Wartime Director of the US Naval Ordnance Laboratory, in 1945. "So long as ships cross the sea this unspectacular weapon will remain a major factor in control of the approaches to harbours, and the shallow straits between seas." His prescient words have been borne out by post-war history. Starting with the Corfu Channel crisis in 1946, when two Royal Navy destroyers were crippled by mines laid off the coast of Albania, the use – or even implied use – of mines has been a regular feature of international crisis and conflict.

During the last 75 years or so, the mine has generally come to be seen as a means of coastal defence, or as an asymmetric disruptor to commercial sea lines of communications passing through straits or chokepoints. Yet, for the wartime US Navy, the mine had demonstrated its utility in an offensive context in the Pacific campaign. Submarines were initially used to covertly lay mines in harbours and anchorages, putting Japanese shipping at risk. From late March 1945, B-29 SUPERFORTRESS bombers were employed to sow minefields in order to block ship traffic in the home islands and so stem the flow of raw materials and food (most of which came from Asia). A second objective was to bottle up the Japanese fleet so it could not interfere with the US landings on Okinawa. As the mining campaign progressed, Japan switched ship traffic to other ports. These were also mined once new routes were identified by intelligence, and those channels that were swept were subsequently re-mined. In all, US aircraft laid over 12,000 mines in Japanese shipping routes and harbour approaches, severely disrupting Japanese logistics and troop movements for the remainder of the war. By August 1945, over 650 Japanese ships had been sunk and little enemy shipping was left afloat or moving.

Yet, despite its strategic-level impact on the Pacific campaign, the mine was a weapon that had limited appeal to the navy's post-war leadership. "Mines were then, and may still be, nobody's business in the Navy," Bennet would later write. "It is generally admitted that a mined channel, provided the mine field can be maintained, is about as surely a block to the passage of ships of substantial size as it would be if filled with rock. However, the use of mines fails to satisfy gung-ho warriors because the miners – unlike those who use shells, bombs, and torpedoes – are not around to see and hear the big bang. As for the high-level types, their lack of long-term interest was once pithily characterised by Elmo Zumwalt: "Mines have no decks for Admirals to pace.'"


Photo: US Navy

Sailors aboard the LOS ANGELES class submarine MONTPELIER (SSN-765) embark a Mk 67 Submarine Launched Mobile Mine (SLMM) at Souda Bay, Crete in June 2021.The SLMM is launched from submarines in areas inaccessible for other mine deployment techniques.


Photo: US Navy

Sailors assigned to Navy Munitions Command East Asia Division Unit Misawa assemble an inert Mk 65 QUICKSTRIKE training mine as part of routine training. A belligerent Russia and the emergence of China as a pacing threat in the Asia-Pacific region are leading the US Navy to think afresh about offensive mining.

Mine Recapitalisation

A belligerent Russia, and the emergence of the Chinese People's Liberation Navy Army as a pacing threat in the Asia-Pacific region, is leading the US Navy to think afresh about offensive mining. The service notes that naval mines can be used to deny sea areas, or inflict damage on shipping to hinder, disrupt, and deny movements and operations involving adversary surface ships or submarines. Resource sponsors in the navy service have acknowledged a revival in interest in offensive mining, and a need to invest in a modernised mine inventory. And while there has been little discussion of mining plans by the navy in public forums, think-tanks and analysts have offered useful insights into the opportunities and options being considered.

In their December 2019 Center for Strategic and Budgetary Assessments (CSBA) report, "Taking Back the Seas, Transforming the US Surface Fleet for Decision-Centric Warfare", authors Bryan Clark and Timothy Walton suggested that mining "may be an attractive option to address the threat of Chinese or Russian submarines and constrain the movement of enemy surface combatants." While pointing out that the upswing in interest in mining had yet to be matched by an increase in investment, or new doctrine, Clark and Walton said that the merging of technologies germane to Unmanned Underwater Vehicles (UUVs), torpedoes and mines offered new opportunities for offensive mining. "This approach would allow mines to self-deploy over relatively short distances, which could reduce the chances of alerting an enemy as to the mine's location, help obscure mine-laying operations, and allow non-stealthy platforms such as surface combatants and maritime patrol aircraft to deploy mines that could travel into more highly contested areas," they wrote.

Pentagon budget plans provide insight with respect to operational priorities and delivery platforms. In the sphere of aerial mine delivery, the US Navy is progressing plans to acquire a capability to accurately deliver air-launched QUICKSTRIKE series mines from stand-off distances as required by a Joint Emergent Operational Needs Statement (JEONS). This includes integration of a Joint Direct Attack Munition (JDAM) GPS guidance tail kit and a glide wing to confer an extended range (ER) capability. Successful demonstrations were performed in 2018-2019 of QUICKSTRIKE mines modified to enable precision placement and stand-off range capabilities. The US Navy first demonstrated the QUICKSTRIKE JDAM capability in September 2018 during Exercise 'Valiant Shield 18' at the Marianas Island Range Complex, while a successful demonstration of QUICKSTRIKE ER (QS-ER) was performed at the Pacific Missile Range Facility, Hawaii, in May 2019.

QS-ER, using the 1,000 lb Mk 64 bomb, is now in development to satisfy the JEONS. The modular kit consists of existing JDAM tail kits, which provide a guidance system and standardised interfaces between the weapon and aircraft, plus a set of folding wings to increase the range of the weapon. Released at an altitude of 35,000 feet, the QS-ER mine will be able to glide approximately 40 nautical miles from its B-52 launch aircraft. In order to meet accelerated timelines, the QS-ER glide kit is being developed under a sole source contract with Boeing, which was in July 2021 awarded a US$58.3M contract by the Naval Sea Systems Command (NAVSEA) for the design and production of non-functional wing glide kits, glide kit prototypes articles and glide kit shipping containers. QS-ER leak resistant bomb bodies are being developed and will be procured through an existing contract vehicle. An initial QS-ER capability is scheduled for delivery in the second quarter of Fiscal Year (FY) 2024 following a planned Quick Reaction Assessment. Additional wing kit production contract options are planned to be exercised in FY 2024, FY 2025 and FY 2026.

Photo: US Air Force

The QS-ER mine marries a 1,000 lb Mk 64 bomb with a JDAM tail kit (for precision delivery) and a wing kit (to increase the range of the weapon).

Separately, updates are continuing for the existing QUICKSTRIKE Mod 3 aerial mine kit. These include continued development of an updated priority target list for the programmable TDD Mk 71 Mod 1, and the introduction of a new Mk 75 safety and arming device developed by Sechan Electronics. Mk 75 qualification testing is planned for early FY 2025, with QUICKSTRIKE Mod 3 fielding to follow later that fiscal year.

Turning to the undersea domain, the Mk 68 Clandestine Delivered Mine (CDM) programme is a 'spiral development' effort that will deliver a system for deployment by the ORCA Extra Large Unmanned Undersea Vehicle (XLUUV) and/or surface platforms in support of a JEONS. This capability allows access to contested environments and reduces risk by using unmanned platforms. Developed 'in-house' by the Naval Surface Warfare Center (NSWC) Panama City and NSWC Indian Head, CDM Increment 1 provides a baseline capability by utilising components from legacy Mk 67 SLMM systems, with initial deliveries beginning back in FY 2020 following a prototyping phase. Pre-planned product improvements will embody the programmable TDD MK 71, remote control arming via acoustic communications (Increment 2), and reversible arming functions (Increment 3) through future upgrades for increased operational flexibility and safety for emplaced minefields.

The CDM programme is also planned to benefit from a new explosive section design that is being developed by the Office of Naval Research (ONR) under its Compact Encapsulated Effector (C-ENCAP) Future Naval Capability programme. Current plans call for C-ENCAP to transition into CDM from 2024.

Encapsulated Effector

Another key part of the US Navy's offensive mining recapitalisation effort is the new HAMMERHEAD encapsulated Anti-Submarine Warfare (ASW) mine system under development by General Dynamics Mission Systems. Being procured as a Maritime Accelerated Acquisition programme to replace the capability previously delivered by the now-retired Mk 60 CAPTOR mine, HAMMERHEAD is designed to complement existing shallow-water mines by providing a pre-positioned maritime mining capability in deeper water depths, and with a wide area of coverage, in order to restrict or deny adversary access to the intended area.

HAMMERHEAD will use the existing Mk 54 lightweight torpedo (modified for underwater launch) as a kinetic effector against submarine targets. The system will use modern sensing and processing technology to enable accurate targeting at increased range, and then release the selfcontained/self-propelled Mk 54 effector to engage the target once detected.

NAVSEA released a competitive Request For Proposals (RFP) for prototype development in January 2021, describing HAMMERHEAD as "a moored-torpedo variant mine system for intermediate to deep depths that has the capability to detect, classify, and defeat ASW targets". It added that the new weapon will be deployed by an unmanned underwater vehicle "to provide overt or clandestine standoff delivery of multiple mines". The US Navy has identified the ORCA XLUUV as a carrier to deploy the HAMMERHEAD encapsulated effector.

The RFP called for the build of five HAMMRHEAD prototype articles, together with the supply of support equipment, interface test assets, mass models, and physical fit check models. Option pricing was additionally sought for up to 80 additional prototype articles. Following evaluation of two proposals, General Dynamics Mission Systems was in September 2021 awarded a US$93M cost-plus-fixed-fee and firm-fixed-price contract by NAVSEA covering the design, test and delivery of HAMMERHEAD prototype articles and other related equipment over a 24-month period. Options in the contract would, if exercised, bring the cumulative value of the contract up to USD 275.6 million, and see work continue through to September 2026.

Initial capability is planned for late FY 2024. A first Low Rate Initial Production contract is scheduled to follow in early FY 2025. The HAMMERHEAD system architecture is intended to enable an evolutionary acquisition approach through the insertion of incremental performance updates to the system. One aspect of this is to transition to the C-ENCAP encapsulation system to allow for the deployment of different 'front end' effectors.

Improved minefield planning is another important part of the navy's mine recapitalisation effort. According to budget documents, these improvements include new targeting algorithms, mine settings, and corresponding damage data for weapon/target pairs into existing minefield planning software. Also included are upgrades to the software tool to optimise minefield planning to account for new precision placement capabilities inherent to the CDM and the QS-ER standoff GPS-guided mine.

ORCA XLUUV to Perform Covert Mine Delivery

Photo: Boeing

The US Navy's ORCA XLUUV programme – which will facilitate covert minelaying in contested environments – is based on Boeing's commercial ECHO VOYAGER vehicle.

The US Navy's ORCA XLUUV programme is an accelerated acquisition effort developed in response to a Joint Emergent Operational Needs Statement (JEONS) in the Indo-Pacific theatre. Essentially an un-crewed mini-submarine, the 80-ton XLUUV is intended to transit an area of operation, loiter with the ability periodically to establish communications, deploy the payloads, and transit home (a notional straight-line transit would be 2,000 nautical miles).

Following an industry competition, Boeing was in February 2019 awarded a USD 274.4 million contract covering the delivery of five XLUUVs and associated support. The company, which is teamed with Huntington Ingalls Industries (HII), has based its platform design on its commercial ECHO VOYAGER vehicle. The modular design of the XLUUV allows for the integration of different payloads in a 34-foot mid-section. The US Navy has indicated that the first of these payload modules will be used for carrying mines, enabling the XLUUV to perform covert minelaying in contested environments. The XLUUV mid-section mission module will be capable of deploying both the Mk 68 CDM and the new HAMMERHEAD encapsulated mine.

HII has built a new facility in Hampton, Virginia, to assemble hull structures for the ORCA XLUUV programme. The first ORCA test asset was launched in April 2022 in Huntington Beach, California.

The US Navy, through the Unmanned Maritime Systems Program Office (PMS 406) in the Program Executive Office Unmanned and Small Combatants, is also pursuing plans for a submarine-launched minelaying unmanned underwater vehicle known as MEDUSA (Mining Expendable Delivery Unmanned Submarine Asset). Designed to meet future submarine delivery of payloads requirements, MEDUSA has been conceived as a tactical clandestine mining system, using an expendable UUV capable of being torpedo tube launched from US Navy submarines. The full system will comprise a medium-class UUV, supporting equipment, and mine payloads.

PMS 406 has previously sponsored a MEDUSA prototyping and demonstration effort to demonstrate the concept of a submarine-launched payload delivery vehicle. The MEDUSA prototype, developed by HII-owned Hydroid under an earlier effort known as CDM/Bull Shark, is believed to have completed at-sea testing from a LOS ANGELES (SSN-688) class submarine.

The MEDUSA demonstration effort has now spawned a programme of record. A contract award for risk reduction, prototype design, fabrication and test activities is currently planned for the fourth quarter of FY 2023. Four prototype units are scheduled for delivery no later than the fourth quarter of FY 2026.

Winning the War at Sea

Reshaping the USMC for Future Naval Campaigns

Peter Layton

For more than a century, the purpose of the United States Marine Corps (USMC) has been to fight for and hold territory. Whether in counterinsurgency conflicts globally, or in major wars in the Pacific, the Corps has focussed on land operations. The only question has been whether the Corps needed forcible entry, large-scale amphibious operations to get ashore or not. All this is now dramatically changing.

America's 'second army' is reorienting itself away from land wars to instead fighting the war at sea. The USMC will now support US Navy (USN) fleet operations, integrate with the USN and emphasise the maritime domain. The USN's needs will now shape the future of the Corps.

Background

The USN considers it must be a globally-dominant naval force that can keep international sea lanes open, deter conflict, and, if necessary, win any war at sea. In pursuit of this, the USN deploys forces well forward. These both form the first line of America's homeland defence and also prevent any adversary during wartime using the world's oceans for its own purposes. To continue accomplishing this mission, the USN plans on becoming a hybrid fleet. The Navy's core will still be manned, multi-mission ships and submarines but these will work in conjunction with unmanned and optionally manned systems operating under, on and above the sea.

The USN's mission is now threatened by the proliferation of precision strike weapons amongst unfriendly states and antagonistic non-state actors. This has combined with recent surveillance and reconnaissance technology advances to give belligerent entities much improved targeting capabilities. The threat now posed was convincingly demonstrated in the 2016 Houthi insurgent anti-ship missile attack on a UAE-operated fast transport vessel, the former Military Sealift Command SWIFT (HSV-2), in the Red Sea. Well-targeted precision strike weapons could potentially drive the US Navy out of many important operating areas and away from regional allies and friends.

In considering such threats, the USN and thus the USMC as well, are using China as the planning benchmark. Over the last thirty years, China has constructed the world's largest navy, developed advanced cruise and ballistic anti-ship missiles and built an integrated system of sophisticated long-range targeting sensors. China's anti-access/area denial network now spreads across the Western Pacific, including to within several regional nations' territorial waters. This impressive capability is now being matched by an increasing aggressiveness across East Asian waters and the Indian border zone. The quality and scale of this potential threat is such that it reinforces the well-established naval maxim to "attack effectively first" if war suddenly breaks out. In this, the key to success is having both faster and more accurate targeting than an adversary.

For USMC planning, the key geographic area is the First Island Chain, a long succession of archipelagos located between China's coastline and the Pacific Ocean. This chain runs down the Kuril Islands along Japan's western coast, to the Ryukyu Islands, Taiwan, the northern Philippines and down into Borneo. In time of war, the USMC would seek to use the First Island Chain as a form of barrier to prevent Chinese naval vessels breaking out into the wider Pacific Ocean. While this is Western Pacific specific, the same concept is considered broadly applicable to other maritime areas, including the Barents Sea, Baltic Sea, Arabian Gulf, and Andaman Sea.

Photo: US Navy

The Australian frigate PERTH launches a surface-to-air missile during exercises with the US Navy in the Philippine Sea. Expanding Chinese anti-access/area denial capabilities are complicating the ability of US and allied navies to operate effectively within the First Island Chain.

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Photo: US Navy

New and emerging technologies such as unmanned and autonomous systems are influencing new USMC operational concepts. Here a V-BAT 128 unmanned aerial system performs a vertical landing onto a US Navy amphibious ship.

The USMC strategy is not just shaped by geography. The promise of emerging technology also has a substantial influence. Artificial intelligence, autonomous systems, robotics, big data, ubiquitous sensors, unmanned vehicles, affordable space-based systems and advanced communications are transforming how wars will be fought in the future. The result is that fleet size alone will not necessarily determine victory in a war; the combination of smart concepts and smart technology may instead be decisive.

The USMC Concept

China's anti-access/ area denial network covers a very large area. The USN plans to counter this by complicating China's attempts to target US naval forces through dispersing and operating in a distributed manner. The USN's Distributed Maritime Operations concept is now informing USMC thinking, which has come to consider the zone from the First Island Chain inwards to the Chinese coast as a single, integrated battlespace. Under the Stand-In Forces concept, the USMC plans to conduct expeditionary warfare within the well-defended littoral zone.

Small size USMC expeditionary units operating from large amphibious ships will be inserted by helicopter, tiltrotor aircraft or landing craft in a distributed pattern across the possibly hostile maritime battlespace. These forces will conduct Expeditionary Advanced Base Operations (EABO) from temporary austere locations within Chinese long-range weapon engagement zones. In accord with the USMC's new fleet support function, EABO will undertake sea denial and sea control tasks, together with a strong emphasis on providing high quality targeting information to naval forces sailing well outside the First Island Chain. The USN distributed operations model involves moving from today's kill chains into kill webs, highly-resilient communication pathways that will allow any nearby warship, submarine or aircraft to engage a hostile target at its discretion. Stand-In EABO may become a key node in future kill webs.

The EABO concept originated as part of rethinking the war at sea but is now being broadened to include countering Chinese grey zone activities conducted below the threshold of armed violence. In this lower part of the competition continuum, the stress is on surveillance and reconnaissance. The Stand-In forces will be able to monitor local sea and air activities for extended periods, and be able to gain and maintain contact on any approaching Chinese warships, Coast Guard cutters and armed militia vessels. In this way, the USMC unit will be able to identify, report and possibly respond to any Chinese malign grey zone behaviour. However, using EABO in such a manner will first require approval from the various nations within whose territory the relevant First Island Chain's islands fall.

The preferred Stand-In Force posture would make extensive use of emerging technologies. Unmanned systems would be placed farthest forward, then a layer of manned unmanned teaming systems and finally outermost, a manned area. The larger, less mobile, and logistically intensive equipment and platforms would be located well outside the potentially hostile areas, advancing only when necessary for particular tactical tasks. The Stand-In Force than acts as a geographically fixed, forward edge behind which friendly naval forces can shelter, manoeuvre and conduct underway replenishment.

EABO need certain characteristics to both survive and perform useful missions. They need to be small, envisaged as reinforced-platoon size and around 50-70 personnel in strength. Staying small considerably reduces the logistic support that EABO will require, allowing them to be more easily sustained over extended periods. This allows persistence; a perceived EABO advantage compared to aircraft and ships. This

Photo: US Marine Corps

The USMC envisages that forward deployed Stand-In forces will be able to monitor local PLAN sea and air activities for extended periods as part of efforts to counter any potential Chinese malign grey zone behaviour.

size also allows Stand-In Forces to have their own organic mobility so they can manoeuvre within the area as the tactical situation requires. Lastly small size helps keep force visual and electromagnetic signature low. Stand-In Forces can only survive inside a hostile long-range weapons engagement zone if they remain hidden. Force survivability is also enhanced by actively using deception and being able to move away quickly if found.

Today and Tomorrow

The USMC is about three years into its ten-year Force Design 2030 modernisation effort. In this time, some USD 16 billion worth of tanks, bridging and towed artillery has been cut to free up funding for the new systems the Stand-In Force concept requires. Considerable experimentation is now underway to refine concepts and doctrine and determine the optimum equipment to acquire. In March 2022, the Hawaii-based 3rd Marine Regiment was converted into the 3rd Marine Littoral Regiment (MLR); it recently participated in the large-scale multi-national RIMPAC 2022 exercise by covering a carrier strike group transit. By 2030, the Okinawa based 4th and 12th Marine Regiments will be similarly converted. Each regiment will comprise a Littoral Combat Team, a Littoral Logistics Battalion, and a Littoral Anti-Air Battalion. New equipment planned includes a medium-size landing ship, unmanned boats and anti-ship missiles.

Photo: US Marine Corps

USMC infantry operate with an Australian Army ABRAMs tank during the Predator's Run 22 exercise. The USMC has divested its own heavy vehicles as part of the Force Design 2030 Modernisation Effort.

The medium-size landing ship will be procured under the planned Light Amphibious Warship (LAW) programme. It is envisaged that it will displace around 4,000 tons, have a stern or bow ramp for ship-to-shore transfer across a beach, be able to embark at least 75 Marines and their equipment, and able to operate within fleet groups or independently. The USMC would like to acquire up to 35 LAWs, allowing nine for each marine littoral regiment with eight in maintenance reserve. However, acquisition of the first LAW was recently delayed until 2025 and only 18 LAWs are projected in most recent USN future planning documents. In the interim, a commercial stern landing vessel has been leased for the 3rd MLR to conduct experimentation. The US Army also has several large landing craft that it wishes to dispose of that could possibly be transferred to the USMC.

Photo: US Marine Corps

The Navy Marine Expeditionary Ship Interdiction System (NMESIS) launcher provides the USMC with readily deployable anti-ship weapons in support of the EABO concept.

More exotically, the USMC has just taken delivery of five Long-Range Unmanned Surface Vessel (LRUSV) prototypes from Louisiana company Metal Shark. These small unmanned craft can be operated optionally manned or autonomously and carry supplies, sensors or loitering munitions to attack small ships. The craft will initially be used by a newly formed LRUSV Experimental Platoon within the Expeditionary Warfare Training Group Atlantic for experimentation, development work and unit training.

The EABO role requires organic anti-ship weapons. The USMC is trialling the Navy Marine Expeditionary Ship Interdiction System (NMESIS), a converted Joint Light Tactical Vehicle (a four-wheeled jeep) carrying two Kongsberg/ Raytheon Naval Strike Missiles. The USMC envisages 108 NMESIS systems being acquired by 2025. The Naval Strike Missile has a 185 km range but with a small warhead is designed only to inflict a mission kill on smaller warships. More ambitiously, the USMC is acquiring some 54 TOMAHAWK Block Va cruise missiles with a range of more than 1,500 kilometres and able to find and destroy larger warships.

More broadly, the USMC still aims to retain a large, if slightly reduced, amphibious fleet of 31 vessels. These ships with their aircraft, helicopters, hovercraft and amphibious combat vehicles will remain over the horizon, on call to support the Stand-In Forces.

A USMC machine gunner. The lightly-equipped nature of USMC Stand-In Forces raises questions as to whether or not they will be considered sufficiently powerful to deter a potential aggressor.

Considerations and Concerns

The Stand-In Forces concept is reminiscent of the Australian and New Zealand Coastwatch organisation during World War Two. Small groups behind Japanese lines very successfully passed time-critical warnings to Allied naval task groups about Japanese ships and air movements. However, not all Coastwatchers survived, suggesting that some USMC Stand-In Forces might not also. These forces are small, with limited self-defence and hope to avoid being targeted while being relatively close to China. EABO may therefore need to rely on passive sensors to try to hide their location but this will reduce their usefulness to distant friendly naval fleets awaiting targeting information. Moreover, the LAWs with their 15-knot planned speed could also be vulnerable to attacks as they insert and support EABO. The Stand-In Force concept will need some rigorous experimentation to devise and validate the best tactics for EABO survival during wartime.

This uncertainty raises further questions over the Stand-In Force concept being able to deter. Deterrence requires an adversary being convinced that defending forces are sufficiently powerful to inflict unacceptable damage. EABO – in being unseen – may make opposing naval commanders uncertain; however, in being lightly equipped, EABO may not suffice to make these commanders change their battle plans. The rejoinder is that, providing communications allow, EABO could call on large-scale strikes from distant friendly naval fleets to help protect them.

Moreover, some fret that the USMC in divesting major land force equipment will make less of a contribution to future land wars. The USMC has a reinforcement role in the event of a major land war in Northern Europe and over focus on Pacific operations may mean it is ill-equipped for this mission. Stand-In Forces may not just need an ally's approval to operate on their territory but could also concern allies in being somewhat lightweight.

On the other hand, the Stand-In Forces concept is an interesting response to a problem that all navies have of operating close to well-defended shores. Importantly, however, the concept only aims to keep adversary surface warships close inshore and away from interfering with friendly activities on sea or land. In that regard, an enemy could decide not to fight, stay in port and practice a fleet-in-being strategy so it can influence war termination negotiations and the post-war period. The low cost of the EABO idea though, combined with its usefulness in peace as well as potentially in war, may make it worth more navies and, perhaps, also a few armies of coastal states exploring.